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BUILDING CONSTRUCTION AND DRAWING.

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BUILDING CONSTRUCTION AND DRAWING:

BY

CHARLES F. MITCHELL,

Lecturer on Building Construction to the Regent Street Polytechnic, London

(Member of the Society of Architects, Member of the London Architectural Association, and Associate of the Sanitary Institute).

Revised by Technical Teachers of the Polytechnic Institute.

COMPILED TO ASSIST STUDENTS PREPARING FOR THE MAY EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT.

FIRST STAGE OR ELEMENTARY COURSE.

Third Edition, Revised and Enlarged.

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PREFACE TO THE THIRD EDITION.

It is very satisfactory that the demand for this little work increases as it becomes more widely known, and that two large editions should be exhausted. The demand for a third edition has given me the opportunity of making considerable improvements both in the text and illustrations. Thus revised, I trust it may still receive the approval it has hitherto obtained.

CHARLES F. MITCHELL.

THE POLYTECHNIC INSTITUTE,
309, REGENT STREET, LONDON, W.
December, 1893.

PREFACE TO THE FIRST EDITION.

It has been my duty, with my respected colleague, the late A. HARLAND, Esq., A.R.I.B.A., to prepare great numbers of students for the Annual Examinations in Building Construction, in the Elementary, Advanced, and Honours Stages, and we felt the great need of a text-book, with illustrations fully dimensioned, containing the latest practice, and that had been thoroughly revised by specialists in each of the building trades. With this object in view, and having the co-operation of my fellow teachers of the Polytechnic Institute, I have compiled this work, ***primarily for our own students***, but trusting that it will be found useful to those in other classes, and to all persons connected with the building trades.

I take this opportunity to thank J. W. Clarke, lecturer on "Plumbing"; G. C. Pope, teacher of "Practical Carpentry"; H. W. Richards, lecturer on "Brickwork and Masonry"; H. J. Spooner, C.E., F.G.S., lecturer on "Engineering"; E. A. Young, lecturer on "Building Construction," for the great assistance rendered by revising the chapters against which their names are placed on page viii, and to E. G. Davey for his valuable assistance in preparing illustrations.

CHARLES F. MITCHELL.

October, 1888.

LIST OF WORKS, ETC.,

REFERRED TO.

In compiling this treatise the author is pleased to acknowledge his indebtedness to the authors of the following works, which he has consulted :—

"Encyclopædia of Architecture"	Gwilt.
"Building Construction"	Harland, A.
"Architectural Surveyors' Handbook"	Hurst.
"Pocket Book of Engineering Formulæ"	Molesworth.
"Carpenter and Joiners' Assistant"	Newland.
"Practical Builder"	Nicholson.
"Notes on Building Construction"	Rivington.
"Builders' Work"	Seddon, Col. H.
'Carpentry, by Hurst"	Tredgold.
"Instruction in Construction"	Wray, Col. H.

Science and Art Examination Papers.

The "Builder."

The "Building News."

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CHAPTER I.

INSTRUCTIONS FOR BEGINNERS.

Drawing Instruments.—The student is advised to obtain the following instruments at least, and, if possible, to draw to a much larger scale all the figured sketches; by doing this, most important points will be impressed on the memory, and a great improvement in the use of drawing instruments will (consequently) be acquired, especially if the student has had the assistance of a qualified teacher.

Architect's double bevelled boxwood scale, having the following scales, two on each edge, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, 3 inches to the foot.

Dividing compasses, compasses with pen and pencil legs, those with needle points preferred. Ruling pen, two vulcanite set squares, 45° and 60° respectively.

Drawing-board of yellow pine, 24 inches by 18 inches by $\frac{3}{4}$ inch, with battens secured at back to allow board to shrink without splitting. (This is the ordinary size used in class work, but larger work will necessitate the use of larger boards).

T square 24 inches long, with ebony edge.

HB pencil for notes, H and HH pencils for drawings. India-rubber and four good drawing-pins, sharp pen-knife, and box of colours.

A set of spring-bows (consisting of dividers, pen and pencil) is (to be) recommended for small work. It is more advisable to have a few good instruments, than a greater number of inferior ones. Care must be taken after using instruments, to put back thoroughly clean and dry, to prevent corrosion.

In cutting the pencil use a sharp penknife, forming a round point as shown in figure 1, which is a good method for ordinary use; or it may be cut to a chisel point as illustrated in figure 2, which has the advantage, especially in the harder pencils, of retaining its edge longer.

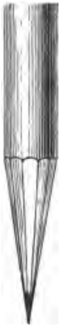


Fig. 1.

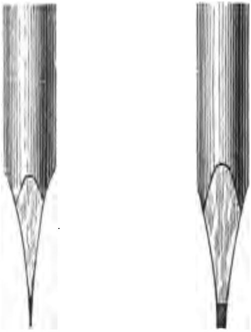


Fig. 2.

Drawing-paper.—This may be easily obtained in the following sizes, which are the dimensions mostly used:—

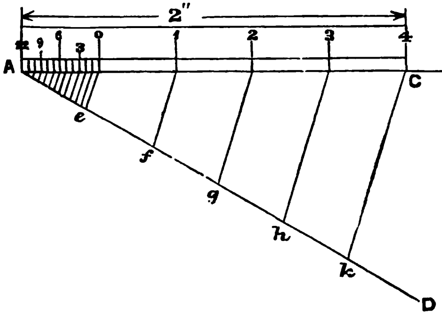
	Inches.
Demy	20 × 15½
Medium	22 × 17½
Royal	24 × 19½
Imperial	30¾ × 22
Double Elephant	40 × 27

These sizes vary slightly with different manufacturers

Whatman's *not* hot-pressed or medium paper is the quality (to be) recommended for finished drawings; it will bear wetting and stretching (without injury), and when so treated, receives shading and colouring easily and freely. Whatman's *hot-pressed* is useful for exhibition pen-

and-ink drawing where care would be exercised to prevent any mistake, as it will not readily admit of alterations. The proper face of paper to draw upon is that side on which, being held to the light, you can read the maker's name. For ordinary working drawings where damp stretching is dispensed with, and no large washes of colours are required, cartridge paper may be used as it is cheaper.

Damp Stretching.—For important drawings, paper is wetted on the back surface, which causes it to expand, and a margin of three-eights of an inch is glued to the board: as the paper dries it shrinks, and the paper between the glued margin becomes stretched, and presents a perfectly plane surface when dry, which can then be used for drawing upon. When drawing is completed, the paper is cut with a penknife, leaving on the board the glued margin, which should be cleaned off with sponge and cold water.



Working Drawings.—If the drawing is to be to an unusual scale, say 5 feet to 2 inches, construct one in the following manner: Draw an indefinite straight line as AB, and mark off 2 inches AC. Draw line AD at any convenient angle, and from A on line AD, with dividers opened any suitable distance, mark 12 equal divisions, A to E; open dividers to distance AE, setting out four equal distances FGHK. Join KC, and from divisions draw parallels to KC, dividing line AC. Complete the scale as in figure 12.

As a rule do not take off with compasses from scale, but use scale direct.

Fix edges of drawing-paper parallel to edges of board (and draw border lines). All working drawings on completion should have scale drawn in bottom left hand corner, or wherever it is more convenient, so that dimensions can at any time be taken with dividers.

Centre and Datum Lines.—If the work to be executed lends itself to be divided up into symmetrical parts as is the case wherever window or door openings and columns occur, centre lines should be drawn through these details. These will be found very convenient whenever any dimension is called into question or reference or alteration has to be made. If the subject offers no opportunity for using centre lines, there is usually some important plane surface, such as party walls, floor levels, etc., which should be drawn and from which all other lines should be measured. If there be no important line or surface convenient, an imaginary one is drawn and all the measurements are taken relatively to same. Such lines or levels are known as datum lines or datum levels, and these with all centre lines should be drawn as a chain dotted line in crimson lake.

Section Lines.—All lines drawn across plans or elevations denoting that sections have been taken at that part, should be drawn as a chain dotted line with Indian ink.

Inking in.—Always use good Indian ink rubbed up in smooth china saucer, and not the ordinary ink which runs when drawings are coloured. Ink in small and then

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large curve lines, after which the straight lines can be easily inked in to the curves. Great care should be taken to have good Indian ink, and not the cheap quality that is sold, as many drawings are spoilt by the ink running when coloured, through neglecting this precaution. All descriptive writing to be executed in Indian ink after colouring. If the ink has a brownish appearance, instead of black, it is insufficiently mixed.

Any cleaning out with india-rubber must be done in one direction, and not rubbed backwards and forwards, which destroys the surface of the paper.

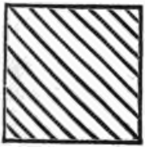
Fig. 3—Brick.

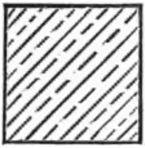
Fig. 4—Stone.

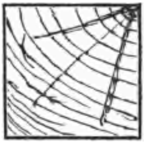
Fig. 5—Wood.

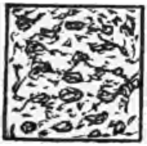
Fig. 6—Concrete.

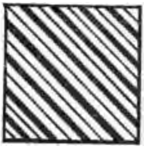
Fig. 7—Wrought Iron.

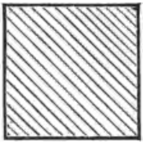
Fig. 8—Cast Iron.

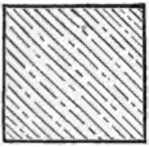
Fig. 9—Steel.

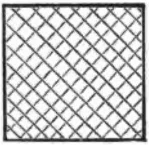
Fig. 10—Lead.

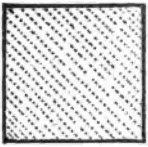
Fig. 11—Brass.

Hatching Sections.—When drawings are not to be coloured, the materials most commonly used may be denoted in section, as shown in figures 3 to 11. This method is adopted throughout this treatise.

When drawings are to be coloured, no sectional or "hatching" lines are to be drawn; the same colour as used for elevations, but of a darker tint, is to be laid on for sections, unless otherwise stated.

Colouring.—It is usual to ink in, before colouring in architectural drawings, as alterations to any error that may creep in after being coloured would disfigure the work. If ink is of good quality it is unnecessary to damp paper before colouring, unless there are large washes. Light colours should go on before darker ones. Colour all parts of same tint straight off, taking care to mix sufficient colour, as it is very difficult to match exact shade; also avoid the common mistake of mixing colour too dark a tint; at the same time it is not considered good to put two washes of colour upon the same part. Camel's hair or sable brushes should be used.

List of Conventional Colours to be used in Preparing Drawings.

Indian Ink.—Lines generally. Lettering. Shading to slopes of roofs.

Gamboge.—Brass or gun-metal. Proposed alterations or additions to existing plans.

Raw Sienna.—Deal floors. Fir unwrought. Buff Brickwork (in elevation), with the addition of a few lines of Burnt Sienna.

Burnt Sienna.—Fir, wrought (except floors). Roads and gravelled surfaces.

Crimson Lake.—Brickwork in plan and section. Lines on which sections are taken.

Venetian Red.—Copper. Red brickwork (in elevation), with the addition of a few lines of Crimson Lake. Tiled floors, roots, etc.

Vandyke Brown.—Freestone masonry, in dressings, etc.

Sepia.—Oak. Earth (in section). Asphalte (a light tint speckled with Indian Ink).

Neutral Tint.—Concrete, speckled with Indian Ink. Shadows, and flat washes to show retired planes of buildings—the deepest for the most distant. Slates, in roofing, etc. Stone walling (light in elevation).

Indigo.—Cast iron. Lead. Zinc. Glass (seen from without). Hard stone, in dressings, floors, steps, etc.

Prussian Blue.—Water. Wrought iron.

Cobalt.—Glass (seen from within). Dimension lines.
Hooker's Green, No. 2.—Grass. Glass in section.
Steel.—Prussian Blue and Crimson Lake.

Dimensions.—All the leading dimensions should be distinctly figured in. Any indifference to this precaution is likely to produce serious mistakes.

Lettering.—For titles and headings, block letters, either upright or sloped, are effective, but for general and descriptive writing an easily written form of neat italics is to be preferred.

Specimen Upright Block.

A B C D E F G H I J K L M N O P Q
R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 0

Specimen Sloped Block.

A B C D E F G H I J K L M N O P Q
R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 0

Specimen Upright Roman.

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z

Specimen Sloped Roman.

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z

SPECIMEN—ITALICS.

a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0

Measurements.—Throughout this treatise a single accent (′) signifies feet, a double accent (″) inches, and (°) degrees.

The items of geometrical knowledge which are necessary to know are stated below:—

Plan.—If the boundaries of the surfaces of solids are imagined to be projected in paths or by lines, perpendicular to a horizontal plane, that portion of horizontal plane enclosed by the projectors is called the plan.

Elevation.—In a similar manner the space covered on a vertical plane by projectors from a solid, perpendicular to the vertical plane, is the elevation.

Elevations are named after the sides seen; as front, back, or side elevation.

Section.—When a plane divides a solid, the cut surfaces are called sections.

Sectional Plans or Elevations.—Are the projections of a cut surface and any remaining part of the solid.

The parts seen from outside in plan or elevation always being perpendicular to the plane that projectors are being taken from, are drawn in firm lines, those unseen in dotted lines to indicate their position.

Isometric Projection.—It is often convenient, especially for details of solids with rectangular faces, to show the three dimensions in one view. This may be accomplished by drawing three lines meeting in a point containing equal angles of 120°, representing length, breadth, and depth to scale, and from the free extremities of these lines draw lines parallel to the other two. It is usual to work with ordinary scales.

Perspective.—This is the science of making representations of objects as they appear to the eye; and is very useful for showing how a proposed object will appear when made, and for illustrating details.

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CHAPTER II.

BRICKWORK.

Brick laying is the art of arranging bricks in such a manner so as to distribute over a greater area any weight that is sustained by it. This result is obtained by what is termed bonding. The duration of a brick wall depends, first, upon the correctness and skill with which the bricklayer bonds his work together, and secondly, in arranging the various thicknesses of the walls to safely resist all external pressure brought to bear, such as the weight from floor and roof, pressure of wind, etc.

The average size of a good stock brick is 8¾″ long, 4¼″ wide, and 2¾″ thick, and the dimensions, including one mortar joint, in this work, unless otherwise stated, will be taken as, length 9″, width 4½″, and thickness 3″. Bricks are usually bedded on the 9″ × 4½″ surface in lime or cement mortar, the upper large surface having an indentation, or frog, as it is sometimes called, which affords a good key for the mortar, as shown in figures 13 and 14.

Bricks are wetted before being used in order to remove loose dust, to afford better adhesion for the mortar, and to prevent the bricks from absorbing too much moisture from the mortar.

Course is the name given to the row of bricks between two bed joints, and the thickness is taken as one brick plus one mortar joint, in this work; unless otherwise stated it will be considered as 3″, or, as technically described, four courses to the foot.

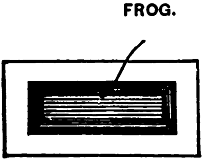
Bed Joints are those mortar joints between the courses:—

(*a*) In walls with vertical faces the bed joints would be horizontal.

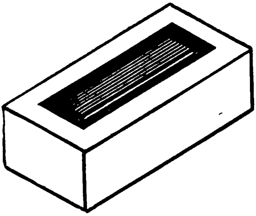
(*b*) In batter walls they would be at right angles to the batter.

(*c*) In arches they come between the voussoirs.

Quoins are the external corners of walls. The name is sometimes applied to the bricks or stones which form the quoins, *e.g.*, quoin brick, quoin stone.



PLAN OF BRICK.
Fig. 13.



SKETCH ELEVATION.
Fig. 14.

When the vertical joints of the face of the wall fall immediately over each other the "perpends" are said to be kept.

Stretchers are bricks laid with their lengths of 9″ on the face of the wall or parallel to the face of the wall.

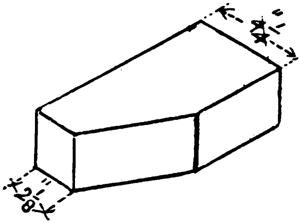
Headers are bricks laid with the width of 4½″ on the face of wall or parallel to the face of the wall.

Bats are pieces of bricks, and are usually known according to their proportion to whole bricks, as ½ or ¾ bats.

Lap, the horizontal distance between the vertical joints in two successive courses, This should be 2¼″.

Queen Closers are bricks made same length and thickness as ordinary bricks, and half the width, but owing to the quantity broken in cartage, the extra expense is usually an objection, and bricklayers form the closers economically by cutting their broken bricks into ¼ brick bats and placing two together to form closers, as shown in figures 24 to 33. This is easier and not nearly so wasteful as to attempt to cut an ordinary brick lengthwise in two.

King Closers are bricks cut so that one end is half the width of a brick, and is used in positions where the greater width at back would add strength to the bond, as shown in figure 15. It usually occurs at rebated openings in Flemish bond walls.



KING CLOSER

Fig 15.

Bond, that is to bind, is the name given to any arrangement of bricks in which no vertical joint of one course is exactly over the one in the next course above or below it, and has the greatest possible amount of lap.

Foundations.—Brick walls are made wider at the base in order to spread the weight of the building over a larger area and produce an equality of settlement. An increase of the amount of brickwork at the base of a wall also brings the centre of gravity of the wall lower down, producing greater stability.

The area of the foundation of any wall depends upon the nature of the ground; thus soft or marshy soil would necessitate a greater width of footings than a good hard subsoil.

When the base of a wall rests upon soft or treacherous ground, it is of no use to extend the bearing surface, unless some provision is made for retaining the supporting material and preventing its lateral escape under pressure.

The methods to be adopted depend upon the requirements of each particular case. Sheet piling surrounding the foundation area is often used; it consists of timber piles cut to fit closely together and driven down to reach firmer ground beneath the subsoil, bound together by waling pieces and iron bolts; the weight is then distributed resting upon a stiff platform which in turn may be supported by piles driven in till every sectional inch of piling is capable of resisting without appreciably sinking 1,000 bls. per square inch by a thick layer of concrete spread over the entire area.

In all cases, the concentration of weights should be avoided in the foundations of any building; nothing more surely tends to produce inequalities of settlement. It is also objectionable for the same reason, to support a building on piers of concrete, which are only connected with each other at their tops; but it is often advisable to fill up holes on the site of a building with concrete, and then to spread a layer over the entire site to distribute the weight.

Footings are the wide courses at the base of a wall, upon which the latter is built. The course that comes immediately upon the concrete should be twice the required width of the wall; thus, in a two-brick wall this course would be four bricks wide. Offsets of 2¼″ are then made on each side of each successive course till the desired thickness is obtained. Walls of two or more

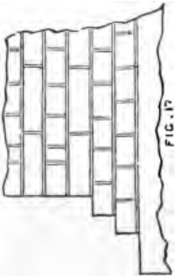


FIG. 17 ELEVATION

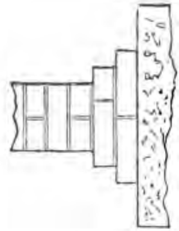


FIG. 16 SECTION

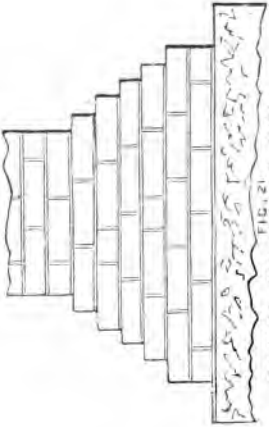


FIG. 21 FOOTINGS FOR 2½ BRICK WALL

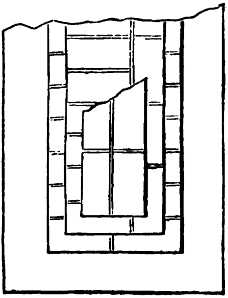


FIG. 18 PLAN

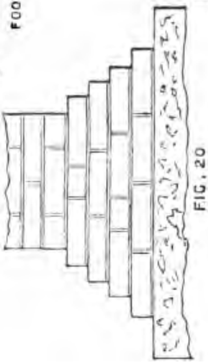


FIG. 20

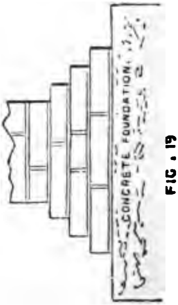


FIG. 19

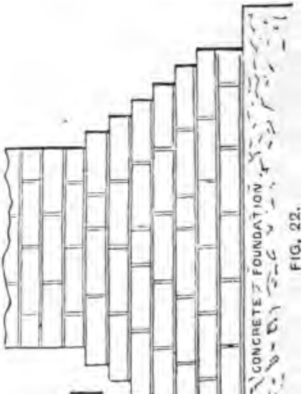


FIG. 22.

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bricks in thickness should have bottom courses of footings doubled.

Figures 16 to 22 give sections of footings and walls in English bond from 1 to 3 bricks in thickness. Trenches are excavated for beds of concrete usually from 2 feet to 7 feet in depth, and 12 inches wider than base of footings (6 inches on each side). Section lines are omitted for sake of clearness.

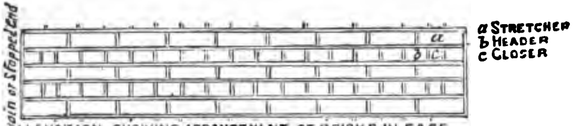
Seddon recommends brick footings to be dispensed with, and substitutes a deep bed of concrete, and as the bed of concrete need not be wider than the width of footings, a saving is made over the ordinary method.

The following three rules are generally adhered to:—To ensure good bond—first, uniform arrangement of bricks, using as few bats or closers as possible; secondly, courses are made to break joint internally as well as externally; thirdly, a closer is always to be inserted next the header at all quoins, and where more than one closer has to be used in the quoin of a wall they are placed immediately behind the face closer.

Hindrances to good bond often occur when facing bricks are used of different lengths and widths to the body of the wall; in 9″ walls where it is necessary to have two fair faces, very frequently facing headers are cut off, as an easy method of getting out of the difficulty as well as a cheap one; but this weakens the wall to a large extent, and it would be better to only attempt to bond in every third or fourth course, as in garden wall bond.

Hoop Iron Bond.—An additional longitudinal tie is often inserted in walls, called "*hoop iron bond,*" usually pieces of hoop iron 1″ by $\frac{1}{16}$″, one row for every half brick in the thickness of the wall. It should be carefully tarred, and sanded before use, and hooked and lapped together at all

English Bond.



ELEVATION SHOWING ARRANGEMENT OF BRICKS IN FACE OF WALL.

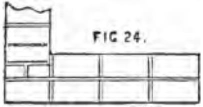


FIG 24.

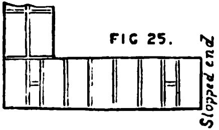


FIG 25.

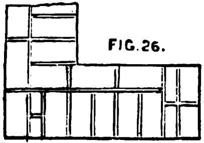


FIG. 26.

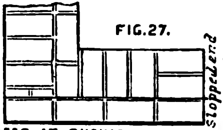


FIG. 27.

PLANS OF ALTERNATE COURSES AT QUOINS 1½ BRICK WALL.

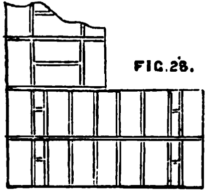


FIG. 28.

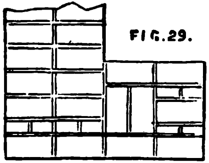


FIG. 29.

PLANS OF ALTERNATE COURSES AT QUOINS 2 BRICK WALL.

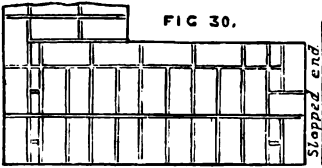


FIG 30.

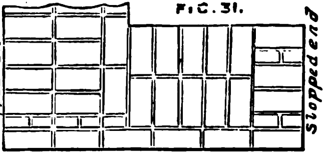


FIG. 31.

PLANS OF ALTERNATE COURSES AT QUOINS OF 2½ BRICK WALL.

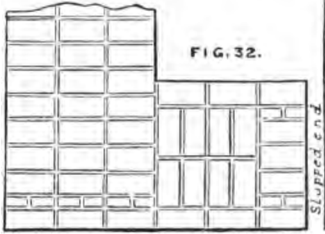


FIG. 32.

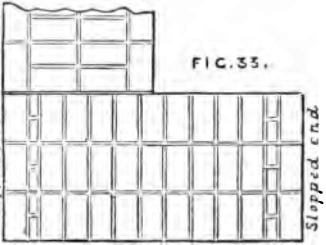


FIG. 33.

PLANS OF ALTERNATE COURSES AT QUOINS OF A 3 BRICK WALL.

angles and junctions. If bedded in two courses in cement, additional strength is gained; pieces of hoop iron may be used with advantage when the bond at any part of a wall is defective.

English Bond.—When the bond is arranged as shown in elevations and plans, figures 23 to 33, it is known as English bond, and sometimes old English bond. It consists of one course of headers and one course of stretchers alternately. In this bond bricks are laid as stretchers only on the boundaries of courses, thus showing on the face of the wall, and no attempt should be made to break the joints in a course running through from back to front of a wall. That course which consists of stretchers on face is known as a stretching course, and all in course above or below it would be headers with the exception of the closer brick, which is always placed next to the quoin header to form the bond, and these courses would be called heading courses.

It may be noticed that in walls, the thickness of which is a multiple of a whole brick, the same course will show either—

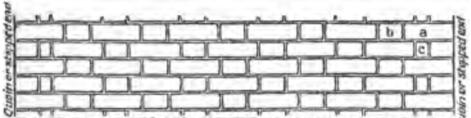
(*a*) Stretchers in front elevation and stretchers in back elevation.
(*b*) Headers ,, ,, ,, headers ,, ,,

but in walls in which the thickness is an odd number of half bricks the same course will show either—

(*a*) Stretcher in front elevation and header in back elevation.
(*b*) Header ,, ,, ,, stretcher ,, ,,

In setting out the plan of a course any width, draw the quoin, or corner brick; then next to the face, which in front elevation shows headers, place closers to the required thickness of wall, after which set out all the front headers, and if the thickness is a multiple of a whole brick, set out headers in rear; if the thickness is an odd

Double Flemish Bond (Flemish Bond, both faces).



ELEVATION SHOWING ARRANGEMENT OF BRICKS IN FACE OF WALL

Fig 34

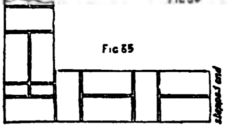


Fig 35

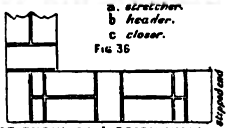


Fig 36

PLANS OF ALTERNATE COURSES AT QUOIN OF 1 BRICK WALL

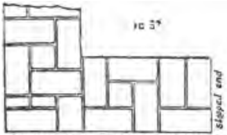


Fig 37

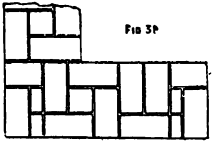


Fig 38

PLANS OF ALTERNATE COURSES AT QUOIN OF 1½ BRICK WALL.

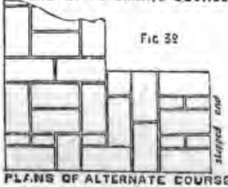


Fig 39

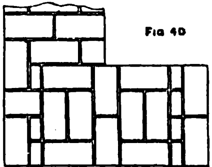


Fig 40

PLANS OF ALTERNATE COURSES AT QUOIN OF 2 BRICK WALL

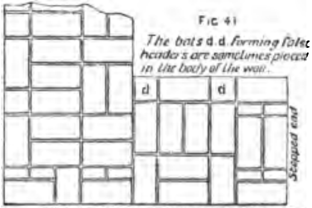


Fig 41

The bats d.d. forming false headers are sometimes placed in the body of the wall.

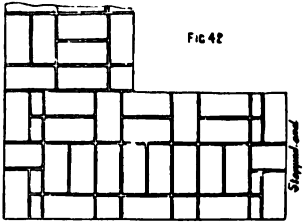


Fig 42

PLANS OF ALTERNATE COURSES AT QUOIN OF 2½ BRICK WALL.

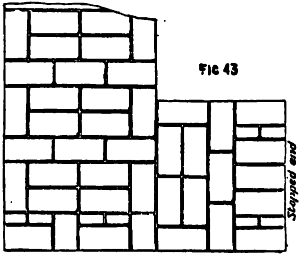


Fig 43

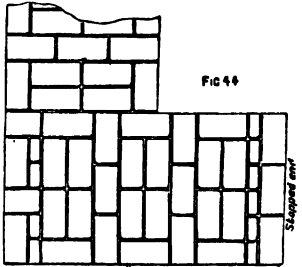
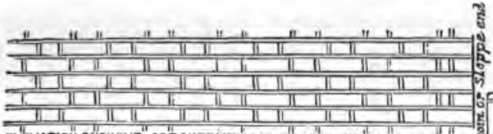


Fig 44

PLANS OF ALTERNATE COURSES AT QUOIN OF 3 BRICK WALL.

Single Flemish Bond (English Bond backing).



ELEVATION SHOWING ARRANGEMENT OF BRICKS IN FACE OF WALL.

Fig. 45.

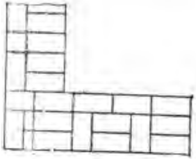


Fig. 46.

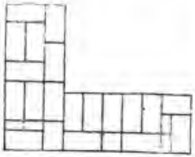


Fig. 47.

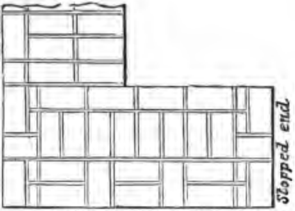


Fig. 50.

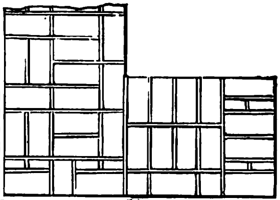


Fig. 51.

PLANS OF ALTERNATE COURSES AT QUOIN OF $2\frac{1}{2}$ BRICK WALL.

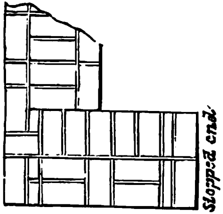


Fig. 48.

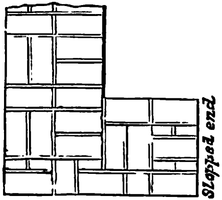


Fig. 49.

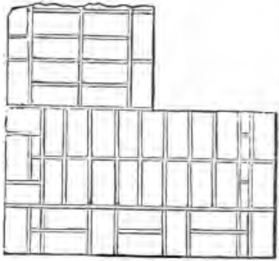


Fig. 52.

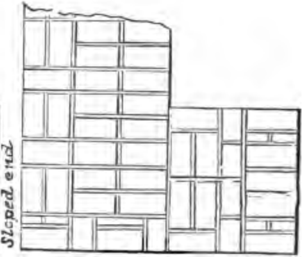


Fig. 53.

number of half bricks, set out stretchers in rear: the intervening space, if any, is always filled up with headers.

Double Flemish Bond has headers and stretchers alternately in the same course, both in front and back elevations, as shown in figures 34 to 44. It is weaker

FIG. 56

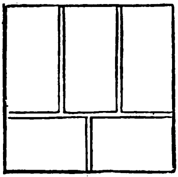


FIG. 54

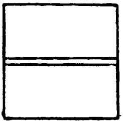


FIG. 59

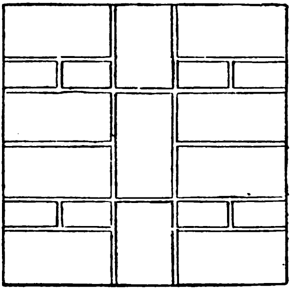


FIG. 55.

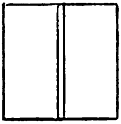


FIG. 57.

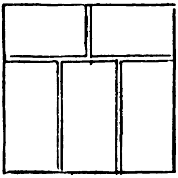


FIG. 60.

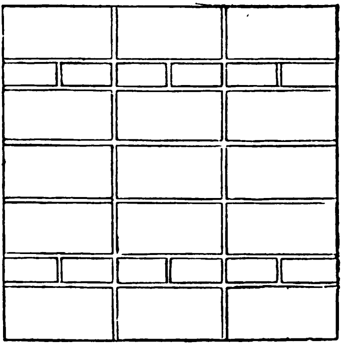
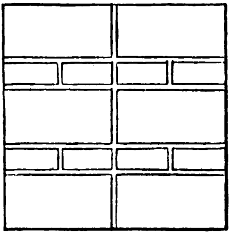


FIG. 58



than English bond, owing to the greater number of bats and stretchers, but is considered by some to look better on the face. It is also economical, as it admits of a greater number of bats being used, so that any bricks broken in transit may be utilised. By using double Flemish bond for thin walls it is easier to obtain a fair face on both sides than in English bond.

Single Flemish Bond.—Consists in arranging the bricks as Flemish bond on the face, and English bond as backing. This is done to gain as much strength as possible, and is generally used where more expensive bricks are specified for facing. The thinnest wall where this method can be introduced is 1½ bricks thick. Plans of alternate courses are given, figures 45 to 53. The front elevations are the same as in double Flemish bond.

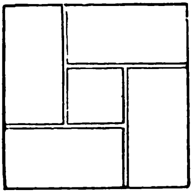


Fig. 61

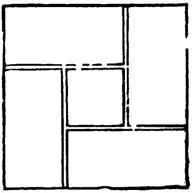


Fig. 62.

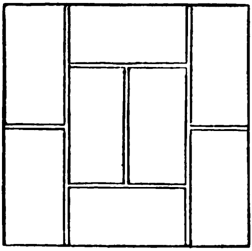


Fig 63.

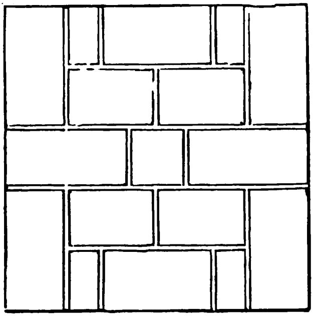


Fig. 64.

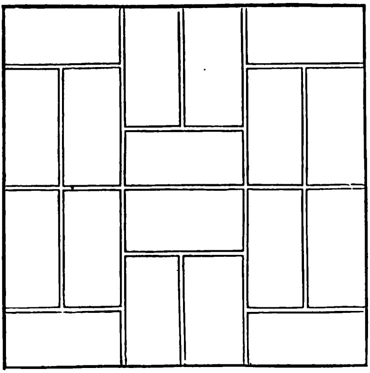


Fig. 65.

Piers.—Piers in brickwork are constructed to carry

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heavy weights from beams, girders, or arches, and care should be taken that the stone template on which the weight rests is of sufficient size to distribute the pressure over an area of wall large enough to prevent crushing or unequal settlement.

Figures 54 to 60 show plans of piers built in English bond, one to three bricks square. It is only necessary to draw the plan of *one* course, as the adjoining courses have the same arrangement of bricks, but placed in such a manner that those in the front elevation of one course are in the side elevation of the next, above or below.

Figures 61 to 65 show plans of piers built in double Flemish bond one to three bricks square.

Reveals are the vertical sides of window or door openings between the face of wall and window or door frames. The horizontal distance between is the clear span of opening.

Jambs are the vertical sides of an opening, and are often parts of rebates, as in window opening, figure 66. They are usually covered with plaster or wood linings.

Figures 66 to 75 show brick reveals, with rebated jambs in English bond.

Arches.—The object of an arch is to carry a weight over an opening. The leading points to be attended to are:—

First: Sufficient support and strength in the abutments, to prevent the arch, when loaded, acting as a lever and overturning them.

Secondly: Strength enough in the arch to prevent the weight above crippling it.

Thirdly: Sufficient area in the pier to carry the weight brought to bear upon it.

Fourthly: All bed joints should be perpendicular to the line of least resistance.

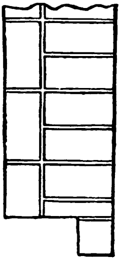


FIG. 69.

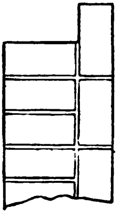


FIG. 68.

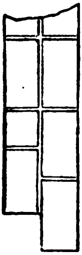


FIG. 67.

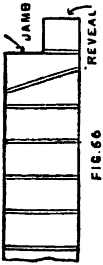


FIG. 66

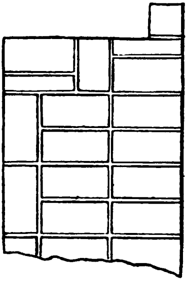


FIG. 72.

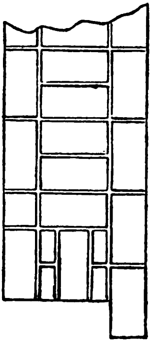


FIG. 71.

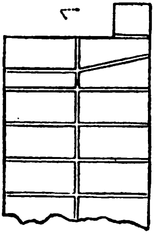


FIG. 70.

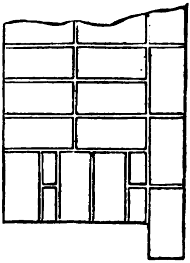


FIG. 73.

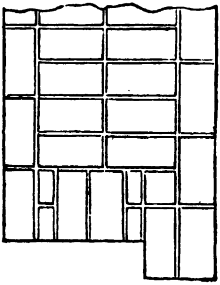


FIG. 75

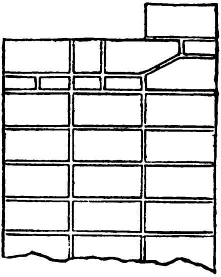


FIG. 74.

Voussoirs are the courses of bricks or stones which compose the arch.

Springers are the extreme or lowest voussoirs of arches.

Skewbacks are the bricks forming the sloping abutments on which the extreme or lowest voussoirs rest, of flat or segmental arches.

Key is the uppermost or central brick or stone of the arch.

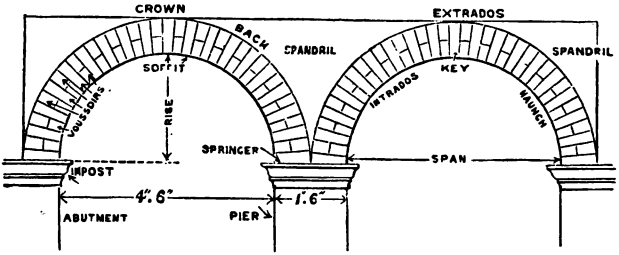


Fig. 76.

Intrados or soffit is the under or concave side of the arch.

Extrados or back is the upper or convex side.

Abutments are the outside supports.

The supports between two arches are called piers.

Impost.—The upper part of a pier or abutment where an arch rests or springs from, generally finished with a moulded cap.

Springing Points.—The starting points where the curves of the arch commences, as seen in elevation.

Span is the horizontal distance between springing points.

Crown is the highest point of extrados of arch.

Rise is the vertical distance between the highest point of the soffit and the level of the imposts or springing points.

Haunch is the name given to lower half of the arch, from the springer or skewback, midway to the crown.

Spandril.—The irregular triangular space between two arches, or the space enclosed by vertical lines drawn from the springing of the extrados and the horizontal line tangent to the crown.

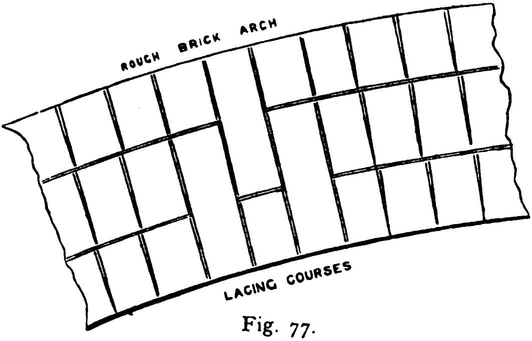


Fig. 77.

Ring Courses of Arches.—The name given to those courses of brickwork that partake of the circular form as seen on face of the wall.

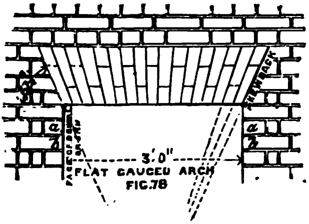
String Courses of Arches.—Are the longitudinal courses as seen on the soffit of the arch.

Lacing Courses.—Ring courses of arches are broken by a bonding or lacing course, as shown in figure 77. These lacing courses prevent the entire weight being carried by any one ring course.

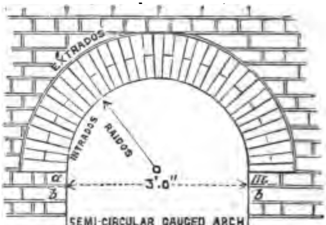
Arches are named after their outline, as flat or camber, semi-circular, segmental, Gothic, and elliptical.

Arches may be either gauged, rough axed, or plain brick arches.

Gauged Arches are used for external faces of walls, and consist of bricks cut and rubbed to form a fine joint, and bedded in lime putty, so that the joints are only $\frac{1}{32}$ inch thick. This is the best work, and is the most expensive.



FLAT GAUGED ARCH
FIG.78



SEMI-CIRCULAR GAUGED ARCH
FIG.81.

The soffit of flat arches should be cambered about ⅛ per foot of span

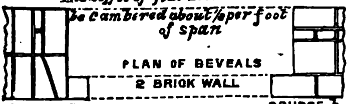


FIG.79

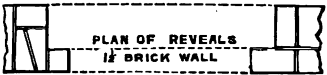


FIG.82.

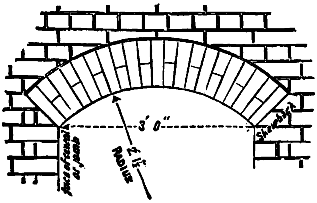


Fig. 80.—Segmental Gauged Arch.

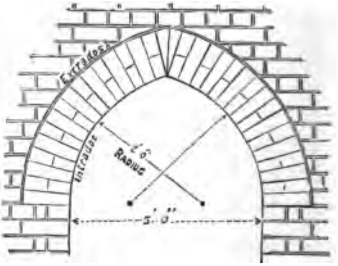


Fig. 83.—Pointed or Gothic Arch.

Four illustrations of gauged arches are given, see figures 78 to 83.

Flat or straight gauged arches are cambered to allow for settlement of wall, and should be sufficient that after settlement has taken place, the soffit line of arch never appears to sag or drop.

Rough Axed Arches.—To avoid the expense of a gauged arch, bricks are sometimes roughly cut to shape to form voussoirs of arch. The roughly-cut surface forms a good key for the mortar and resists the sliding tendency of the voussoirs, but the joints being $\frac{3}{16}$ inch thick, have not the neat appearance of gauged work, and should only be used for external work in warehouses, workshops, etc. An illustration is given in figure 415.

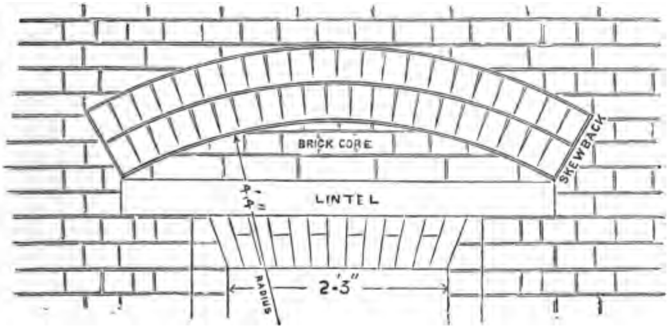


Fig. 84.

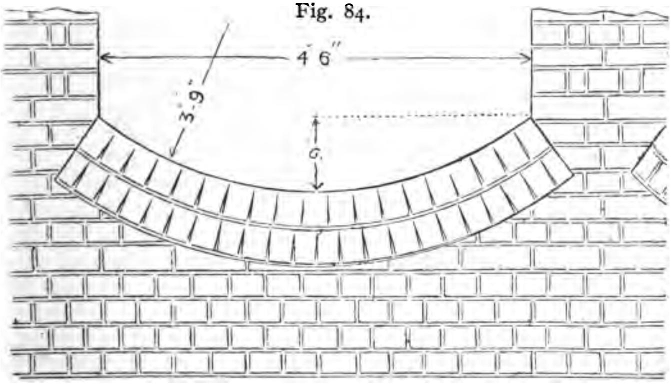


Fig. 85.

Rough Relieving or Discharging Arches are usually formed by laying ordinary bricks on edge (without being cut or rubbed), on rough centres, or turning-pieces, or on a brick core shaped to the required curve as in figure 84, or on a curved wood lintel, illustrated in figure 87. It will be seen that the joint will be much wider on the extrados than on the intrados, as all the joints will be V shaped in elevation. If arches of this description were built in 9-inch rings this defect would be serious; consequently these arches should be constructed in 4½ inch rings, as shown in figure 84, which to a great measure reduces the imperfection.

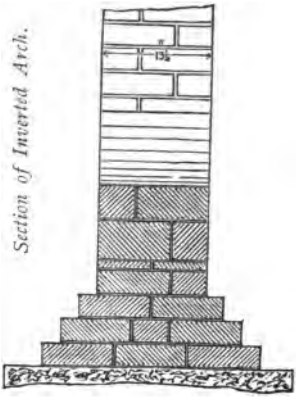


Fig. 86.

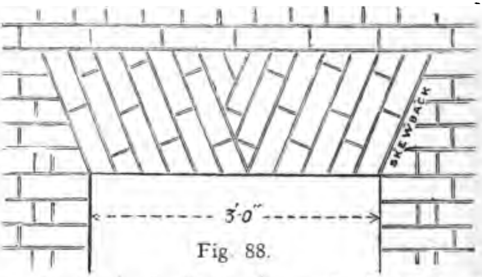


Fig. 88.

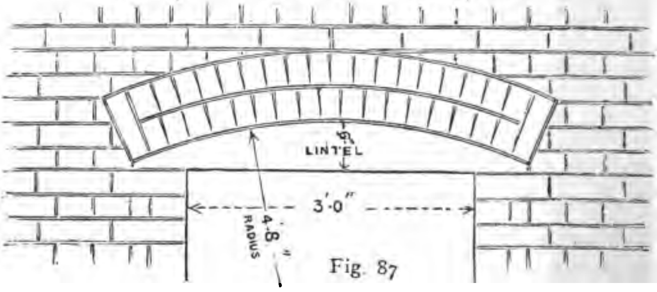


Fig. 87

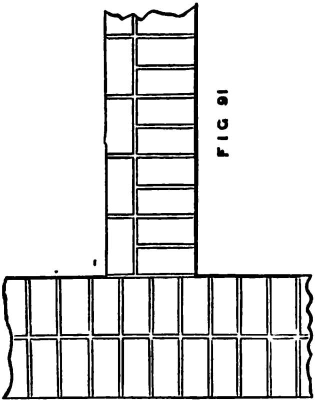


FIG 91

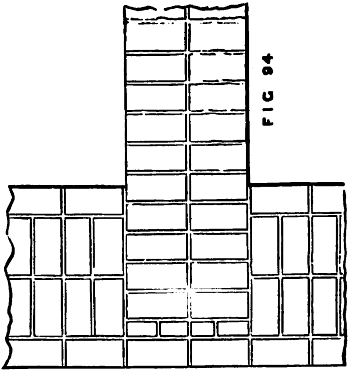


FIG 94

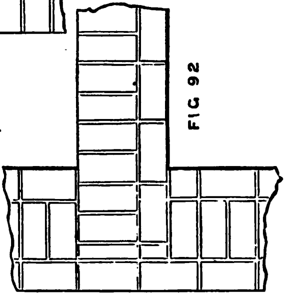


FIG 92

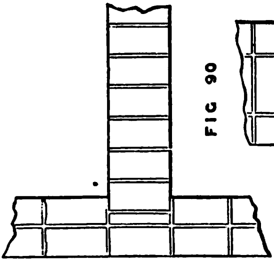


FIG 90

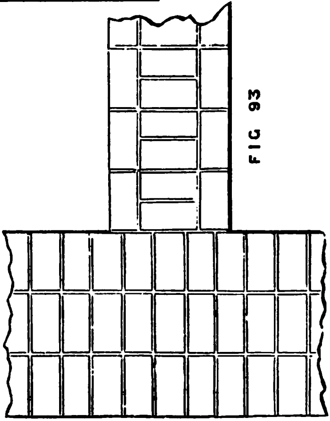


FIG 93

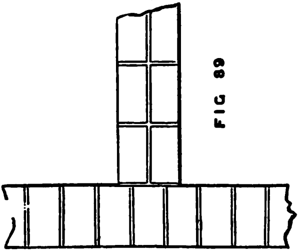


FIG 89

This method is used chiefly for internal arches to distribute the weight over openings on to the piers or abutments, or to distribute the pressure carried by piers over a greater area, as in the case of inverted arches, as illustrated in figures 85 and 86.

Figure 87 shows method of using wood lintel as turning piece, and is to be recommended for internal arches with flat soffit, for this reason, that if the lintel is destroyed by fire there is no brick core to fall down, and the arch is uninjured. Breeze is now extensively substituted for wood for lintels of this form.

Figure 88 shows another rough brick arch, which is known as the French or Dutch arch, and is often used for external arches that are to be plastered over to avoid the expense of a flat gauged arch. It is only used in rough work, and is of weak construction.

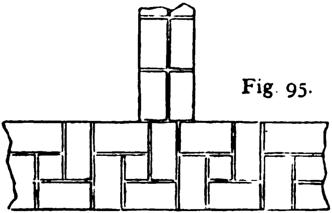


Fig. 95.

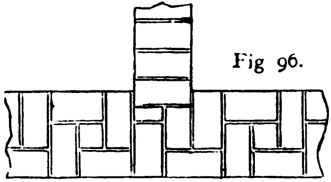


Fig 96.

Trimmer Arches.—Arches carrying hearths in front of chimney breasts, and having an abutment against the trimmer or trimming joists, are called trimmer arches, as shown in figure 221.

Junction of Walls at Right Angles.—Figures 89 to 94 show the methods employed to tie party or division walls with main wall.

Figures 95 and 96 illustrate the junction of 1½ brick Flemish bond with 1 brick English bond.

Stretching or Chimney Bond should be used only for walls half brick thick, as for partition walls. All bricks are laid as stretchers upon the face.

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Sussex Bond, Scotch Bond, garden or boundary wall bond, are the names given to walls that are built with three stretchers and one header in same course, constantly recurring, as shown in elevation, figure 97. This method is used in walls one brick thick that are seen on both sides, as it is easier to obtain the two fair faces by using stretchers than headers, the length of which usually vary.

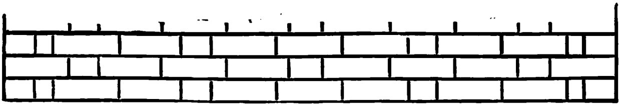
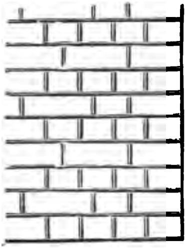


Fig. 97.

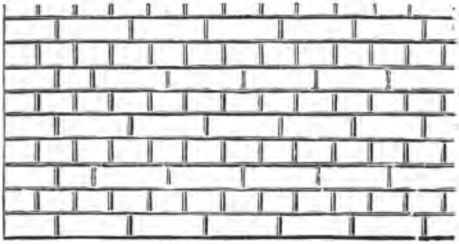
Heading Bond.—All bricks show as headers on face. Used chiefly for rounding curves, and has but little longitudinal strength.

English Cross Bond. — A class of English bond. Every other stretching course has a header placed next the quoin stretcher, and the heading course has closers placed in the usual manner.



ELEVATION ON RETURN.

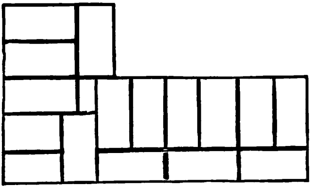
Fig. 98.



ELEVATION SHOWING ARRANGEMENT.

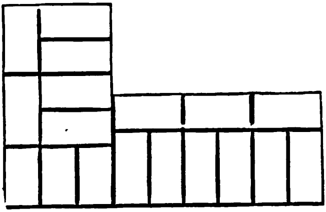
Fig. 99.

Dutch Bond.--In every alternate stretching course a header is introduced as the second brick from the quoin, three-quarter bricks are used in the stretching courses at the quoins, and the closers are dispensed with in the heading courses, as shown in figures 98 to 103; the longitudinal tie becomes much greater, and the appearance of the elevation is certainly superior to much of the very inferior work one is accustomed to see as examples of the modern bricklayer's skill in bonding. Should there be a fracture, it is supposed to throw it more obliquely.



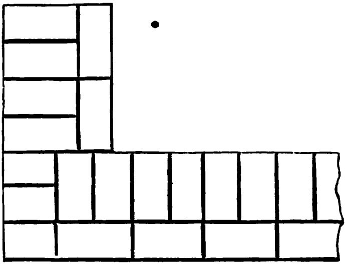
COURSE.3.

Fig. 100.



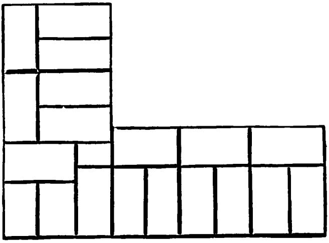
COURSE.4.

Fig. 101.



COURSE.1.

Fig. 102.



COURSE.2.

Fig. 103.

Diagonal Bond.—Consists of bricks laid diagonally in body of walls, not less than two bricks in thickness, and then only in stretching courses. It should only be done at intervals in the height of three or four courses.

Herring Bone Bond.—Somewhat similar to diagonal bond, excepting that bricks rake in opposite directions, from centre line of the wall. This form of bonding is greatly used in paving.

Copings are constructed in brickwork set in cement to form waterproof tops, and prevent any water getting into the interior of wall. Two sections are shown in figures 104 and 105.

Corbelling.—When a projection has to be carried, as in the case of a chimney breast, without taking supports from the footings, the method of corbelling is sometimes resorted to, which consists usually of 1⅛″ offsets, to the required projection. Figures 106 and 107 show this method applied to carrying wall plates. But this arrangement is not to be recommended, as a sudden blow is likely to fracture the bricks which are unsuitable to act as cantilevers.

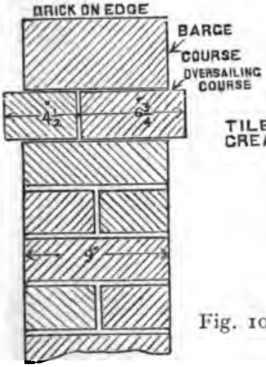


Fig. 104.

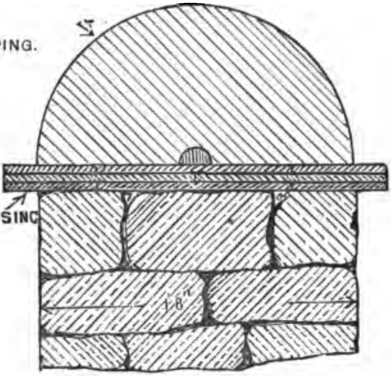


Fig. 105.

String Course.—Is the name given to a horizontal projecting course, carried along the face of wall, anywhere between plinth and cornice, as in figure 106, to give a pleasing effect.

Plinth.—A horizontal and usually projecting course built at base of wall, as in figure 107, to protect the wall from injury, and give additional strength.

Cornice.—The horizontal projection at the highest part of a wall. This is usually moulded, and arranged to form an ornamental feature; or, again, it is the moulded projection that crowns or finishes the part of which it is the highest member.

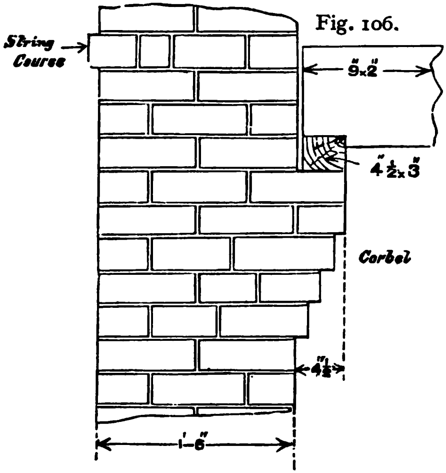


Fig. 106.

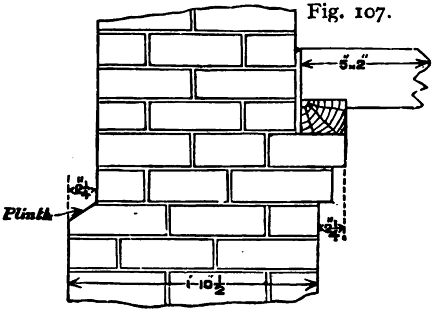


Fig. 107.

Bond Timbers.—It is now generally acknowledged that timbers should not be built in walls to tie or bond them in their length. They are superseded by hoop iron bond, as described on page 15, for the following reasons:—Bond timbers are liable to shrink and become loose, and in time, owing to the absence of a free circulation of air, are subject to the dry rot and perish; they are also liable to be attacked by fire, and, at a critical moment, the walls at that section are practically reduced in thickness by the width of the timber.

Wall Plates should not be built in walls, for the same reasons as bond timbers.

Lintels are small beams to carry the filling-up material, and are used over openings to form square heads under relieving arches; this method is better for fixing purposes, and stronger than straight gauged arches.

Wood Lintels are used either as turning pieces, as in figure 87, over which a relieving arch is built, or as in figure 84, to carry the brick core upon which the relieving arch is built, which must not rest on the lintel, but spring from its extremities, so that if destroyed by fire, the strength of the arch is unimpaired.

Breeze or Concrete Lintels.—Seddon recommends flat lintels to be made of 6 of breeze to 1 of Portland cement; this can be fixed to, and is not subject to shrinkage, or destruction by rot or fire.

Breeze Bricks have the same advantages as breeze lintels; they are greatly used in thin chimney breasts, where wood in any form is objectionable, and in any position for fixing joiners' work, as shown in figure 406.

Wood Bricks, of same dimensions as ordinary bricks, have been used to form fixing surface in brickwork, as shown in figure 406, but they are objectionable, because they shrink, and become loose or are liable to rot.

Wood Plugs are wedges cut on the twist, they are usually driven between the joints of brickwork to obtain a fixing for joiners' work, as shown in figure 406, but unless carefully fixed are not to be recommended, as the wall is often damaged by that operation.

Wood Joints are lengths of wood, 4½ inches by ⅜ inch, built into walls at intervals, or wherever fixing is required, as shown in figure 406. The wood practically does not shrink in thickness; it is the best mode of fixing in most situations, but has to be inserted while the brickwork is being carried up.

CHAPTER III.

MASONRY.

Stone Walling may be divided under the following headings:

1. Rubble. 2. Block in course. 3. Ashlar.

Rubble walls are those built of thinly-bedded stone, generally under 9 inches in depth, of irregular shapes as in random rubble, or squared as in coursed rubble.

Block in course is composed of squared stones usually larger than coursed rubble, and under 12 inches in depth.

Ashlar is the name given to stones, from 12 to 18 inches deep, dressed with a scabbling hammer, or sawn to blocks of given dimensions and carefully worked to obtain fine joints.

The length of a soft stone for resisting pressure should not exceed three times its depth; the breadth from one-and-a-half to twice its depth; the length in harder stones 4 to 5 times its depth, and breadth, 3 times its depth.

Bond, Lap and Course have the same meaning as given under brickwork.

Through or thorough stones are those which are laid across the entire thickness of wall, to tie or bond it, but are considered objectionable for the reason that if any projection has to be taken off at the back, to present a fair face, it would disturb the setting of the adjoining masonry, and damp is more likely to show on the interior of walls where the continuity of the material is uninterrupted.

Headers.—The name applied to stones, the lengths of which are $\frac{2}{3}$ to $\frac{3}{4}$ thickness of wall, and are laid across it.

Bonders.—May be either "throughs" or "headers."

Grout.—Is a thin mortar, which is poured over the stones when brought up to a level surface to fill up any openings between the interior stones caused by careless or inferior workmanship.

Spalls.—Are broken pieces of stone.

Sinking.—When a surface is sunk below the face of a stone as in a chase, a weathered surface, or a rebate, it is known as a sinking.

Rebate.—Is a sinking—showing in section a rectangular slip taken away from the arris or edge.

Weathering.—When the face of a stone is inclined to the horizontal to throw off water it is said to be weathered, as in sills, cornices, etc.

Footings.—The object of footings is the same as in brick walls. Stone footings should be large rectangular blocks. Square stones in plan are not so good as oblong. All stones in the same course must be the same height, but all courses need not necessarily be the same depth. The breadth of set-offs need not exceed 3 or 4 inches.

Where the expense of stone is an objection, footings may be made of bricks or deep beds of concrete, as already described on page 15.

Bed Surface.—The bed surface must be worked in one plane surface. Masons to form thin joints often make the beds hollow; this is bad, as it is liable to spall: all the pressure will be thrown on the outer part, which is liable to flush or burst the face of the stone.

Scabbling or Scappling.—That is taking off the irregular angles of stone; is usually done at the quarry, and is then said to be quarry pitched, hammer faced, or hammer blocked, and when used with such faces the stone is called rock or rustic work.

Hammer Dressing.—Roughest description of work after scabbling.

Chisel Draughted Margin.—To ensure good fitting joints in hammer-faced stones, a smooth surface about an inch wide is cut with a chisel, forming a margin on the face of stone, as in figure 114.

Galleting.—Is the name given when sharp bits of flint, called spalls, are inserted in the mortar of rubble walls to give a pleasing effect.

Random Rubble is the name given to stones that are not squared.

Random Rubble set Dry.—In the stone districts boundary walls are built of rubble set without mortar in courses about 12 inches high, provided with a waterproof top to keep water from getting into the body of work, and bursting it in frosty weather.

Uncoursed Random Rubble set in Mortar.—The stones are used as they come from the quarry, care being taken to select them as uniformly as possible, the bond being obtained by fitting in the inequalities of the stone, and by using one bond stone every super yard on face; any openings between stones to be pinned in with spalls. If good mortar is used, walls built of random rubble should be made one-third thicker than that necessary for brick walls.

In the following figures P stands for plinth, B for bonder, and C for coping. Figures 108 and 109 show elevation and section respectively.

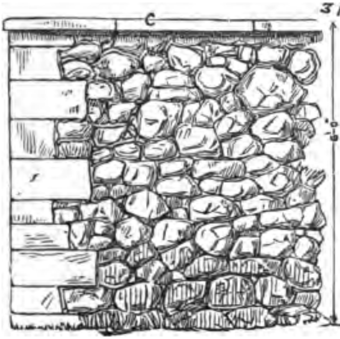


Fig. 108.

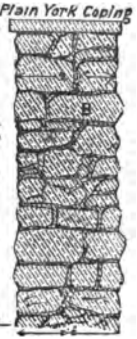


Fig. 109

Random Rubble built in Courses.—This consists in forming horizontal beds at intervals of 12 to 18 inches, every stone being bedded in mortar, as illustrated in figures 110 and 111. To save expense in bedding each stone in mortar, masons bed only the stones on faces of wall (which, by the way, is not a good practice), and at these levels

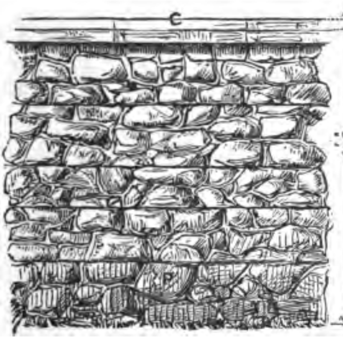


Fig. 110.

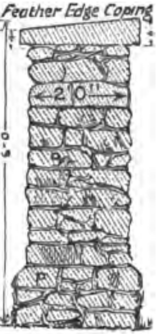


Fig. 111.

pour a pail of thin mortar, called grout, to fill up any cross joints between stones, taking care not to let any run over the face of wall.

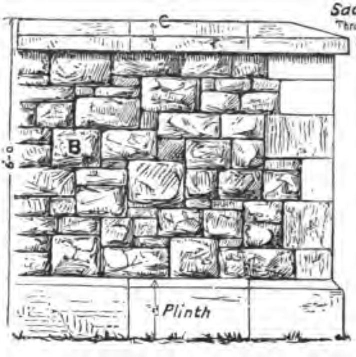


Fig. 112.

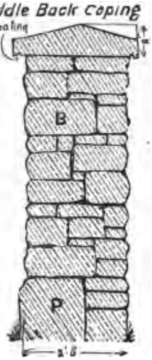


Fig. 113.

Uncoursed Squared Rubble, sometimes called irregular coursed or snecked rubble, are stones roughly squared and hammer or axe faced, the vertical depth of the stones usually being less than 9", as shown in figures 112 and 113.

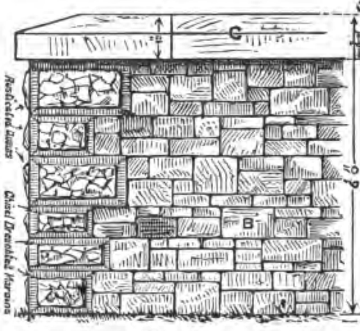


Fig. 114.

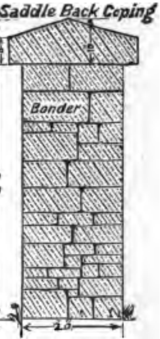


Fig. 115.

Squared Rubble built in Courses.—Figures 114 and 115 show squared rubble brought up to level beds, with hammer-dressed quoins and chisel-draughted margins.

Regular Coursed Rubble.—In this kind of work all stones in one course are squared to the same height, usually varying from 4″ to 9″, as illustrated in figures 116 and 117, and are generally obtained from thin but regular beds of stone.

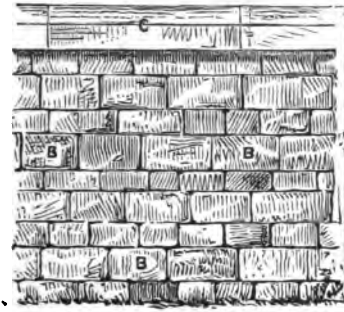


Fig. 116.

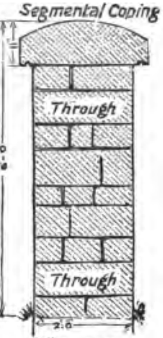


Fig. 117.

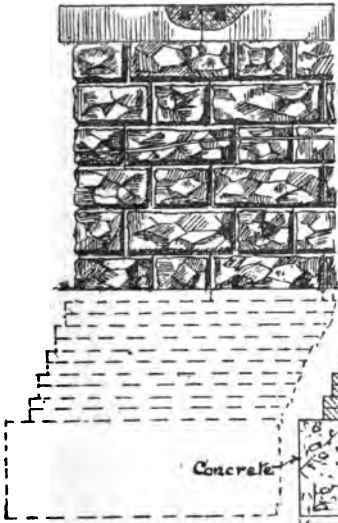


Fig. 118.

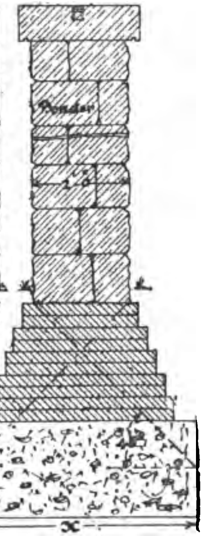


Fig 119.

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Block in Course is the name applied to stone walling, chiefly used by engineers in embankment walls, harbour walls, etc., where good work is required. The stones are all squared and brought to good fair joints, the faces usually being hammer-dressed, and are generally under twelve inches in depth, as shown in elevation and section figures 118 and 119. Block in course closely resembles coursed rubble, or ashlar, according to the quality of the work put upon it.

Fig. 120.

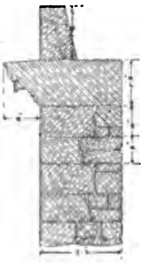
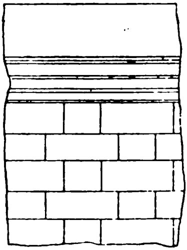


Fig. 121.



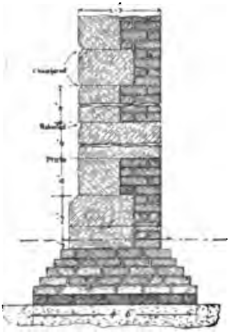


Fig. 122

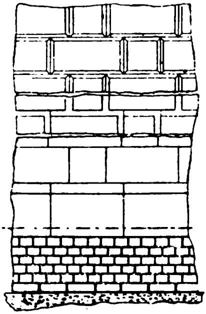


Fig. 123.

Ashlar.—Ashlar is the name applied to stones that are carefully worked, and are usually over 12″ in depth, and have joints not more than $\frac{1}{8}$ inch thick.

As the expense would be too costly to have walls built entirely of ashlar, they are constructed to have ashlar facing and rubble backing, as in figures 120 and 121, or ashlar facing and brick backing, as in figures 122 and 123; but, as the backing would have a greater number of joints than the ashlar, the backing should be built in cement mortar, and brought to a level at every bed joint of the ashlar, to ensure equality of settlement.

The ashlar facing may be plain, rebated, or chamfered, as illustrated in figure 122, and looks best when laid similar to Flemish bond in brickwork.

Arches are described as semi-circular, segmental, etc., according to the outline of their soffit. Stone voussoirs are always marked from templates, and carefully cut to the required shape.

The names of parts are similar to brick arches described on page 28. Figure 124 shows an opening spanned by a stone lintel, the weight of the wall above being carried by a stone relieving arch.

Figures 423 and 424 show section and elevation of a stone lintel, part of the weight of wall above being carried by brick discharging arch at back.

Figure 125 is an elevation of a stone lintel, with the stones above arranged to relieve the lintel of part of the weight of wall.

Figures 126, 127, and 128 illustrate lintels or flat arches constructed of stones joggled or dowelled together.

Semi-circular Stone Arch in Brick Wall.—Figure 129 is an elevation showing a method of cutting voussoirs to suit brickwork.

Dressings.—Stones are said to be dressed when their faces are brought to a fair surface; but any stones which are cut or prepared and are used as finishings to quoins, window and door openings, and may be applied as an ornamental feature, such as quoin stones, window and door jambs, are described as dressings.

Quoins.—In rubble and inferior stone walls, quoins are built of good blocks of ashlar stone to give strength to the wall. These are sometimes worked to give a pleasing effect, and when hammered, dressed and chamfered, as in figure 114, are said to be rusticated. They are, at times,

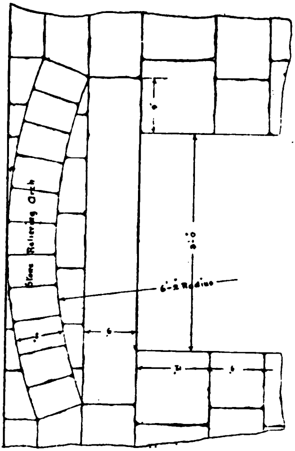


Fig. 124.

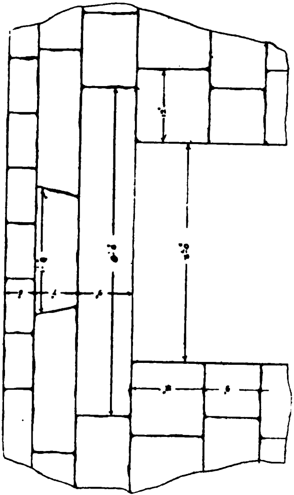


Fig. 125.

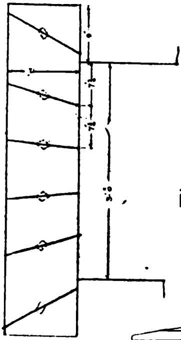


Fig. 126.

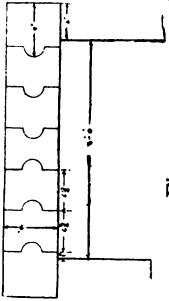


Fig. 127.

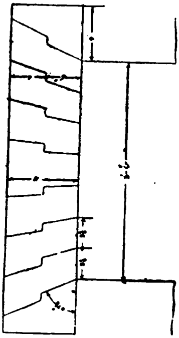


Fig. 128.

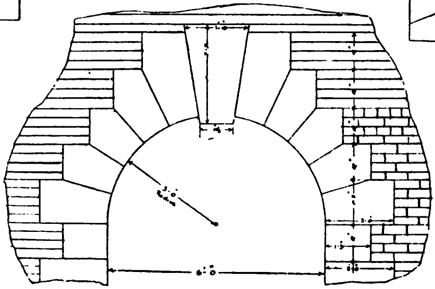


Fig. 129.

merely built with a rough or quarry face, as in elevation figure 118.

Window and Door Jambs.—For purposes of strength these should be of cut stone, attention being given that each course is securely bonded. For that reason it would not be advisable to build them of rubble. Figures 130 and 131 show alternate courses, one showing the stones forming the window jambs acting as stretchers, and the other a through stone forming the face of reveal and the face of rebated jamb.

Sills.—Are the lower horizontal members of openings, and those in stone are usually of one length, being pinned in cement to both sides of the opening. They should be fixed after the carcase of a building has been finished, and any settlement that was likely to occur through a number of wet mortar joints has taken place. They may be either plain and square, as in figure 391, or sunk, weathered, throated and grooved for metal water bar, as illustrated in figures 419 and 420.

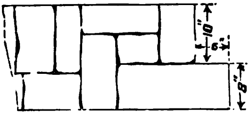


Fig 130.

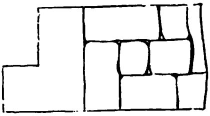


Fig. 131.

String Courses.—Are horizontal projecting bands of stone, as in figure 132, often carried below windows, and are of importance, imparting a feature to the building.

Plinth.—Is a horizontal projecting course built at the base of a wall, often chamfered as in figure 122. In a tuscan column it is the square member at the base.

Cornices.—The moulded course of masonry crowning buildings of the classic styles, or of those structures which partake of the character of those styles, are called cornices, as illustrated in figure 120.

Blocking Course.—A course of stones erected to make a termination to the cornice (see figure 120), the height of which should equal the projection of the cornice, and is often used as one side of a parapet gutter.

Saddled or Water Joint.—To protect the joints of cornices and other exposed horizontal surfaces of masonry the sinking is sometimes stopped before the joint, and weathered off as shown in figures 133 and 134. Any water passing down the weathered surface is guided away from the joint. The expense of this joint often prohibits its use.

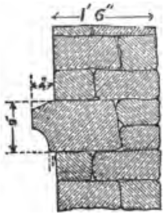


Fig. 132.

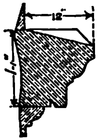


Fig. 133.

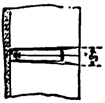


Fig. 134.

Copings.—Are the highest and covering course of masonry, forming a waterproof top, to preserve the interior of wall from wet, which in frosty weather might burst the wall. Figures 108 and 109 show parallel copings which should only be used for inclined surfaces, as on a gable or in sheltered positions. Figures 110 and 111 give section and elevation of feather-edged copings, which throw water off on one side of walls, and are necessary for parapet walls of crowded thoroughfares. Saddle-back is the name applied when the upper surface is weathered both ways, as in figures 112 and 113, and segmental when the section of coping shows the upper surface to be a part of a circle, as in figures 116 and 117.

Throating.—Are grooves on the under surfaces of copings, sills, string courses, etc., acting as drips for any water that would otherwise trickle down, and disfigure the walls, as in section, figure 113.

Rebated Joint. — When stones are fitted together, similarly to the wood joint shown in figure 232, they are said to be rebated; but if they are on inclined surfaces, the rebate should be made as shown in figure 147, which effectually keeps the water out of the wall. The stone forming the upper part of each rebated joint often projects about ⅜ inch above the lower, to obtain shadows necessary for a good appearance.

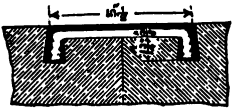


Fig. 135.

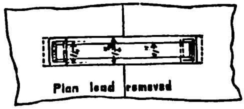


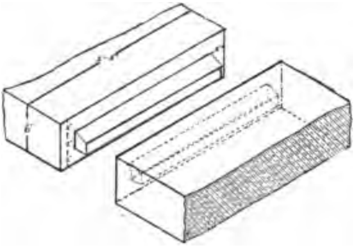
Fig. 136.

Cramps.—Are pieces of metal bent at both ends to secure stones together, and fixed as shown in figures 135 and 136, when greater strength than that of mortar is needed. Another method is to make the mortices in the stone the exact distance apart of the length of the cramp between the turned down ends, the extremities of the cramp being bent inwards till they make an angle of about 80° with the body of same, the cramps are then sprung into position; this has the tendency of drawing the stones together. In ordinary work they are applied to copings, cornices, and in situations where they are liable to slide, as on the ramp of a gable end.

They are made of wrought iron, cast iron, copper and bronze. Bronze is the best material, and was used by the Romans; copper is next, but is often considered too expensive for modern buildings; cast iron is better than wrought, as it does not rust to the same extent when exposed to a damp medium.

A sinking should be made in the stone, and the ends of the cramp jagged. Cramps may be run in lead; but as lead and iron form a galvanic couple, one of the metals will in course of time gradually disappear. A better method for external work is to paint the cramps, and set them in Portland cement.

Iron cramps put in hot and surrounded by asphalte is the method recommended by Gwilt, as for ever to preserve the metal from oxidation.



Figs. 137, 138.

Figures 135 and 136 show section and plan of securing copings with cramps run with lead.

Joggles.—When a projection is cut out of the solid of a stone, and a corresponding groove or recess is cut out of another, it is known as a joggle, and is used to form the joint between two stones. The labour in cutting and the material wasted causes the joint to be too expensive for common use, and it is only employed in parts of buildings, such as thresholds and landings. This joint should be made with the best Portland cement, and projection made to taper, as in figures 137 and 138, so as to enter easily.

Stones of lintels or flat arches if cut as in figure 127, so that a projection of one voussoir fits in the corresponding sinking of the adjoining voussoir, are said to be joggled.

Tabling.—When stones have to resist great lateral pressure, as in the case of walls exposed to the sea, a projection is sometimes cut on the bed of one stone and a corresponding sinking in the bed of the other, as shown in figure 139, so as to prevent any tendency to slide. This operation is very expensive, and is now performed by long slate bed dowels, set in Portland cement, as used in the New Tower Bridge.

Dowels.—The method of securing by dowels is not nearly so expensive or wasteful as joggling or tabling, and answers for most purposes equally as well.

A sinking is made in each stone, as in figure 140, exactly opposite each other; these may be circular or rectangular.

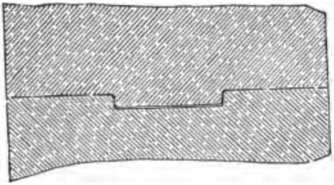


Fig. 139.

Dowels of stone, slate, or metal are made to fit these, and slightly tapered at ends that they may enter easily. Copper is the best, but expensive; iron the strongest, but likely to crack the masonry during oxidation. Slate or hard stone run with cement or brimstone, is found to answer very well. When placed in the centre of the bed of a stone they are known as bed dowels, as in figure 141. The bed dowels used in the New Tower Bridge are of slate, and often used of the dimensions 2′ 0″ × 2″ × 4″, and when set in cement have the appearance of a black joggle. Of late years the manufacture of Portland cement has been brought to a high state of perfection, which has greatly improved its stress resisting properties, and stones are often dowelled together by this material alone, as shown in figure 142, and when after the cement has set attempts have been made to force asunder such joints, the stone has often fractured first.

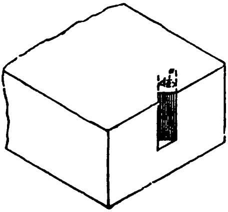


Fig. 140.

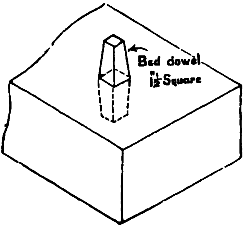


Fig. 141.

Lead Plugs.—Stones may be connected together by means of lead plugs in this manner. Mortises are made in the vertical face of joints, exactly opposite each other, the lower surface of mortise being inclined for lead to enter easily, and to form a dovetail when set, a groove having been cut from the mortises to the top, so that when placed together they may form a channel, through which molten lead is poured from the upper surface of stones, as in figures 143 to 145.

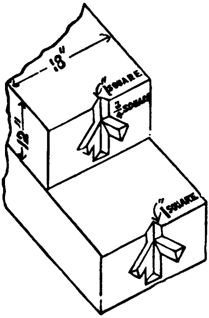
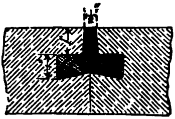


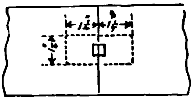
Fig. 142.

Rag Bolt.—The ends of the bolts are often fixed by having the end that is let into the stone jagged, and is run with lead, or sulphur and sand, the mortises being dovetail shaped, as in figure 146, to secure them from any upward pressure.



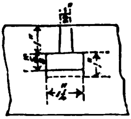
Section

Fig. 143.



Plan

Fig. 144.



Elevation of Hole

Fig. 145.

Templates.—A piece of stone placed under the end of a beam or girder to distribute the weight over a greater area, as in figures 154 and 155.

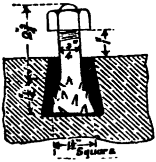


Fig. 146.

Corbel.—Is a piece of stone projecting from a wall to support a weight that is placed upon it, as in figure 224.

Skew Corbel.—Is a projecting stone at the lowest part of the triangular portion of the gable end of a wall supporting the starting piece of coping, as shown in figure 149.

Kneeler.—The lowest stone of the triangular portion of a gable end of wall. It should be a long stone, to tail well in the wall, as shown in figure 148.

Saddle or Apex Stone.—Highest stone of a gable end cut to form the termination of two adjacent inclined surfaces, as shown in figure 147.

Lacing Course.—Owing to the absence of bond in flint walls, at intervals, courses of bricks, three or four deep, are inserted to give strength to the wall and bring it to a level surface. These courses do not always show on the outside.

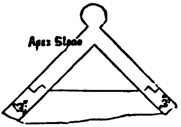


Fig. 147.

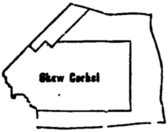


Fig. 149.

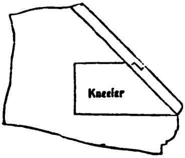


Fig. 148.

Sometimes the name is applied to a horizontal band of stone placed in rubble walls to form a longitudinal tie.

CHAPTER IV.

GIRDERS.

Definition.—Members of buildings which are in one piece, or built up to form one member and used to span openings and support loads, are called girders, and may be either straight or curved and of various sections.

They may be of (*a*) wood, (*b*) wood, halved, reversed and bolted, (*c*) flitched beams, (*d*) built-up beams, (*e*) trussed beams, and when entirely of metal may be of cast iron, wrought iron or steel. The sections of the two latter may be rolled or built up as plate, box, lattice, or Warren girders.

Beams fixed at one end and free at the other are called semi-beams or cantilevers, and when supported or fixed at both ends, beams.

A girder resting on two supports is called a beam, the top of which, under a load, would be in compression, while the lower fibres would be in tension. The neutral axis is in an imaginary plane, passing through that part of a beam neither in tension or compression.

Bressummer, or breastsummer.—Is a girder with a wide supporting surface, acting as a lintel; as in the example of a beam supporting a brick wall over a shop front.

Wood Girders.—These are formed by sawing, reversing, and bolting timber, as in figures 150 and 151. By reversing is meant not only turning the cut faces outside, to

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detect any defects and to ensure its being thoroughly seasoned, but also to change the ends, so that the butt end of one piece is against the top end of the other, which ensures equal strength throughout.

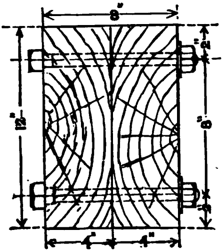


Fig. 150.

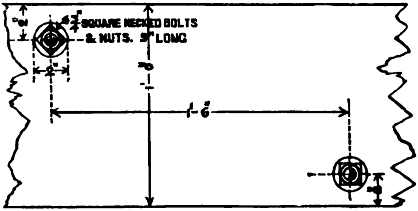


Fig. 151.

Flitch Girder.—To further strengthen a wood girder, a wrot iron plate or flitch is inserted between the cut timber and bolted, as shown in figures 152 and 153. To prevent the iron girder riding on the iron flitch when the timber shrinks, the iron is kept $\frac{1}{4}''$ from the top and bottom surfaces.

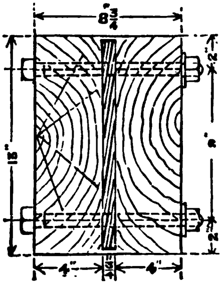


Fig. 152.

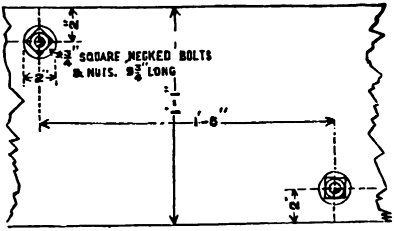


Fig. 153.

Built-up Girders.—Three methods are shown in figures 180 to 183.

Cast Iron Girders.—Cast iron crushes with an average of 45 tons per square inch, and fails in tension with an average of 7 to 8 tons per square inch.

The best shape for cast iron beams is that of I section, the tensional flange being 4 to 6 times the area of compressional flange.

The depth is usually $\frac{1}{10}$ to $\frac{1}{15}$ the length, and width of compressional flange $\frac{1}{30}$ to $\frac{1}{40}$ the length.

All castings should vary in thickness gradually, and stiffeners should be cast about every 3 feet apart.

Sharp corners are a source of weakness, and should be well rounded or triangular fillets, called feathers, cast at all internal angles.

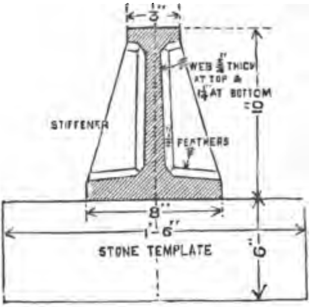


Fig. 154.

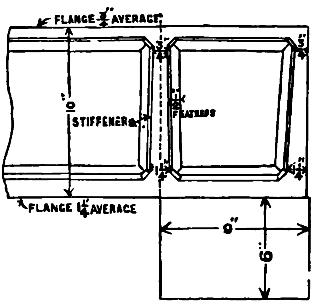


Fig. 155.

Figures 154 and 155 show section and part elevation of a cast iron girder, used as a beam supported at ends, resting on stone template, the top flange being in compression and the bottom flange in tension.

Cast Iron Cantilever.—Figures 156 and 157 show section and part elevation of girder, fixed one end and free at the other. This is sometimes called semi-beam or cantilever, and the upper would be the tensional flange and the lower the compressional flange, the strains induced being exactly opposite to those set up in the corresponding upper and lower flanges of the beam.

Figure 158 is a section of a cast iron girder fixed both ends, where each flange would at different parts be under tensional and compressional strains. Beams are said to be fixed when they are bolted at ends, or if they are continued over a number of supports, the parts over the inner spans may be considered as fixed.

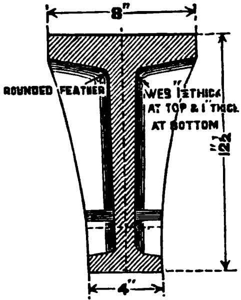


Fig. 156.

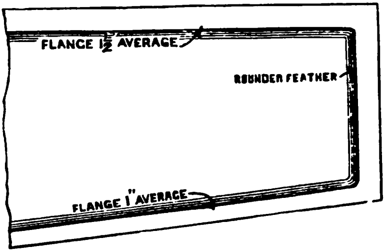


Fig. 157.

Cast iron girders are not considered so reliable as wrought iron girders, as they may contain serious flaws hard to detect, and do not withstand sudden changes of temperature as well as wrought iron. Cast girders have

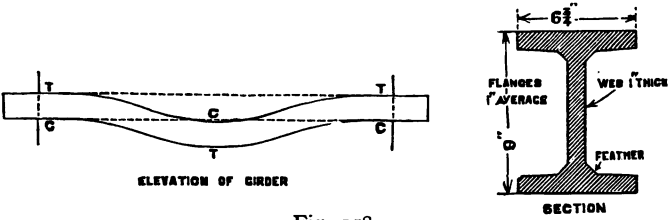


Fig. 158.

snapped suddenly when cold water has been thrown upon them while they have been in a heated state, as is often the condition in a burning building.

Wrought Iron and Steel Girders.—Owing to the above defects in cast iron, and the great improvement in the manufacture of wrought iron and steel, which can readily be obtained of any required section, girders of the two latter materials have come greatly into use. They can be adapted with facility to any of the requirements of construction; and may be satisfactorily tested by taking small pieces of the material used, and subjecting them to the stresses they are required to resist. The effect of heat on wrought iron or steel is to cause it to expand considerably, for which reason girders of these materials should never be fixed at both ends.

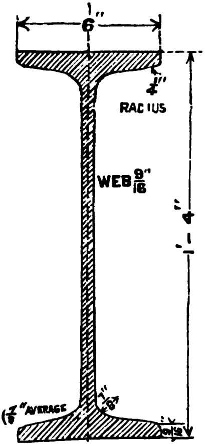


Fig. 159.

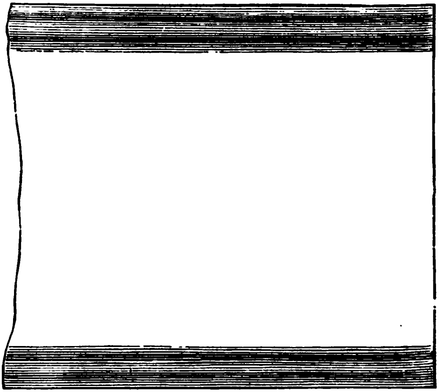


Fig. 160.

The following table shows the relative strengths in tons of cast iron, wrought iron, and steel, as most commonly used in ordinary construction:—

	Tension.	Compression.	Shearing.
Cast Iron	7 to 8	40 to 45	12
Wrought Iron ..	25	16 to 17	22
Steel	30	30	24

Wrought iron crushes with an average of 17 tons, and fails in tension with a pull of 22 tons. In practice for small beams this difference is disregarded, and joists are rolled with two equal flanges, which can be easily obtained to a depth about 20 inches. Figures 159 and 160 show section and part elevation of a rolled iron joist.

Many forms of composite and patent girders are constructed by riveting plates to the flanges of rolled iron joists.

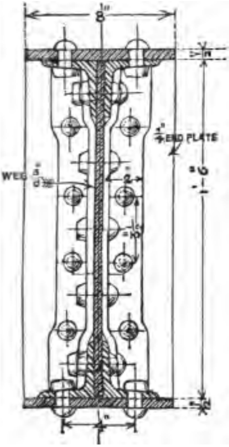


Fig. 161.

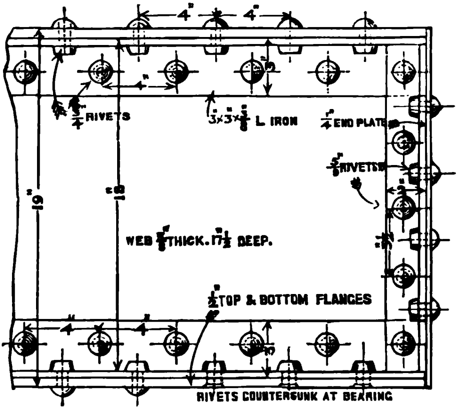


Fig. 162.

Plate Girders.—For girders over 12 inches in depth it is considered more economical to build them of riveted plates, angles and T irons, and to strengthen the webs and flanges with stiffeners of T or angle irons. Stiffeners may be simply angle or tee irons, cut to fit and riveted between the flanges and against the longitudinal angle irons, a level surface being made with the latter; a vertical packing piece having a width equal to the stiffener and of the thickness of the longitudinal angle irons. Figures 161 and 162 show section and part elevation and method of fixing end plates. The connecting angle pieces shown in these figures are bent and dispense with packing pieces, but are more expensive.

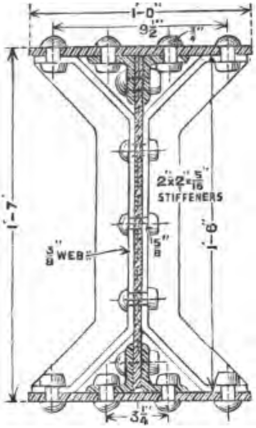


Fig. 163.

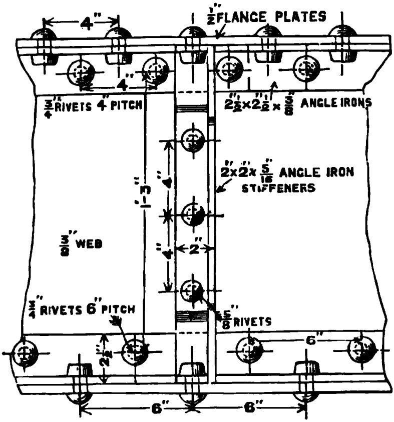


Fig. 164.

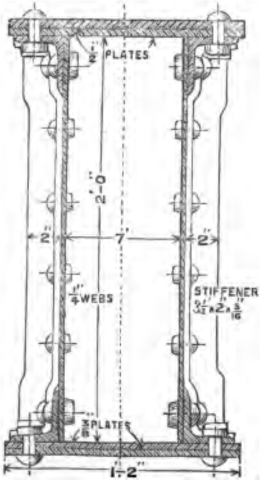


Fig. 165.

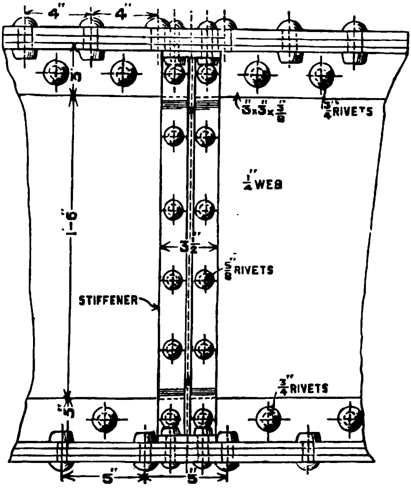


Fig. 166.

Figures 163 and 164 show section and part elevation of plate girder with cranked stiffener.

Box Girders.—For large spans, those of about 50 feet, girders are constructed with two webs, as shown in figures 165 and 166. Box Girders are slightly stronger, section areas being equal, than plate girders, but should only be used when large enough to be painted inside.

CHAPTER V.

JOINTS IN CARPENTRY.

Stress and Strain.—Stress is the name given to an external force acting upon material; and the strain is the amount of such material or the alteration in length, or the change induced from its normal condition.

Beams undergo various strains under different conditions; should a force be applied that stretches or pulls the beam, it is said to be in tension as in the case of a tie-beam, and all members in tension may be considered as ties.

If the force is crushing or pushing, the beam will be in compression as in a short pillar, and all members in compression may be considered as struts.

If a load or pressure be applied at right angles to the length of a beam it will cause a bending or cross strain, as when a floor joist is carrying weight. It may be noticed that the tendency of the upper part is to become hollow or concave, such fibres are in compression, and the lower in tension. Somewhere between the two will exist fibres neither in tension or compression, and the line indicating the position of these fibres is known as the line of neutral axis, or the line of no strain, which in a perfectly elastic material would be in the centre of the section.

If a force acts with a twisting or wrenching tendency the piece strained is said to be in torsion, a strain not frequently met with in timbers of buildings, but occurs in screws and in parts of machinery.

Shearing is a cutting or sliding strain; but in woodwork, when the force shears the beam in the direction of its fibres, it is more particularly described as detrusion, as in the case of the foot of a principal rafter causing the end fibres of beam to have a tendency to slide along the grain; and leaving shearing strain to imply that the force acts at right angles to the grain, as in the example of a loaded beam at the points of supports where the shearing stress is the greatest.

Designing Joints.—In designing joints the following principles, as laid down by Professor Rankine, should be considered:—

1. To cut the joints and arrange the fastenings so as to weaken the pieces of timber that they connect as little as possible.
2. To place each abutting surface in a joint as nearly as possible perpendicular to the pressure which it has to transmit.
3. To proportion the area of each surface to the pressure which it has to bear, so that the timber may be safe against injury under the heaviest load which occurs in practice, and to form and fit every pair of surfaces accurately in order to distribute the stress uniformly.
4. To proportion the fastenings, so that they may be of equal strength with the pieces which they connect.
5. To place the fastenings in each piece of timber, so that there shall be sufficient resistance to the giving way of the joints by the fastenings shearing or crushing their way through the timber.

Classification of Joints.—Joints may be arranged under the following heads:—

1. *Lengthening of Beams, Struts and Ties.*

Lapping, fishing, tabling, scarfing, building up.

2. *Joints for supporting Beams on Beams, Plates, or Posts.*

Notching, cogging, halving, housing, mortise and tenon, chase mortising, joggle, foxtail wedging, tusk tenon, tenon and housed, dovetail tenon.

3. *Joints for Struts and Ties.*

Oblique tenon, single abutment, double abutment, cast iron shoes.

4. *Joints for Ties and Braces or Plates and Ties.*

Dovetailing, notching.

5. *Joints for Struts and Beams.*

Single abutment, mitreing, birdsmouth.

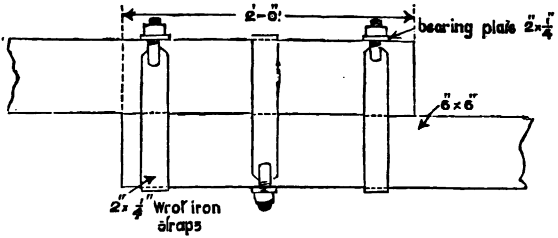
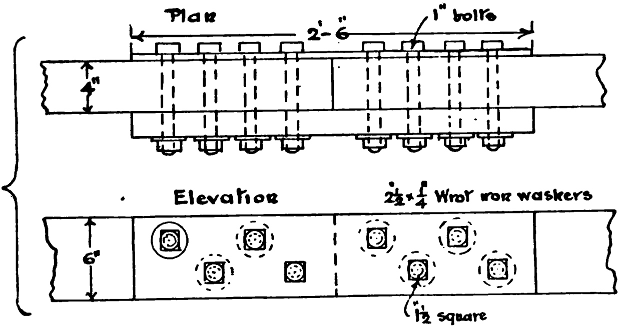


Fig. 167.

Lengthening of Beams.—Beams may be lengthened in various ways to suit the particular stress that the timber has to resist. This is rendered necessary if the desired length is not obtainable in the market.

Lapping.—Consists in resting the end of one piece on the end of another piece, and securing same if to resist tension with bolts, if compression straps, as in figure 167, or as in scaffolding by ropes and wedges. This joint has a clumsy appearance and should only be used for temporary structures. Where the ends are required to be level the length should be composed of an odd number of pieces.

Fishing.—Where two pieces of timber have their ends abutting, and a plate of wood or iron is secured on each



ELEVATION

Fig. 168.

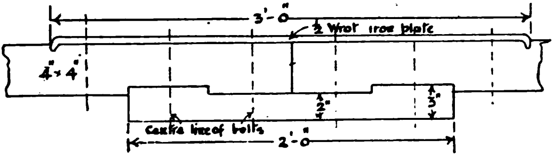


Fig. 169.

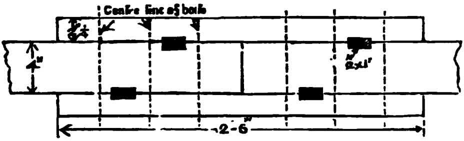


Fig. 170.

side by means of bolts, it is said to be fished, as in figure 168. For lengthening ties a plain fished joint is most economical for labour and material. In the event of the timbers shrinking and thus causing great stress upon the bolts, keys of hard wood or folding wedges are inserted to assist the latter, as in figure 170 or sometimes tabling is

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resorted to, as in figure 169, by bedding portions of one beam into another; but as this is costly and reduces the section of the beam, it is not often employed. Where iron fish plates are employed the ends are turned in, and care must be taken to arrange that the indents in wood to receive the ends are not exactly opposite each other, with the object of retaining as great a section as possible. In designing a fished joint the following rules are *based* upon those given by Seddon :—

1. The strength of fished joints depends on the effective sectional area of fish-plates, together equal in tensile strength to the effective sectional area of the tie.

2. On the sectional area of bolts on either side of the joint being sufficient to resist shearing. In practice it is usual to take the sectional area of the bolts as equal on either side of the joint to at least one-sixth the effective sectional area of the tie, when the bolts are in single shear and one-twelfth when in double shear.

3. On the placing of the bolts in such a way and at such distances from the ends of the timbers, as to prevent their drawing through them.

4. The bearing area of the bolts must be sufficient to prevent their cutting their way through either the timbers or the fish plates.

Scarfing and Fishing.—The following difference may be noticed between a fished and a scarfed joint.

In the fished joint the total length of pieces joined is not reduced, while in the scarfed joint the pieces are cut and fitted over each other so as to keep the same breadth and thickness throughout, the total length of pieces joined only being less than the sum of the separate lengths.

Scarfing.—Where two pieces are required to be joined and neatness is required before strength, this method should be preferred.

Figure 171 shows a tabled joint, and if this is calculated according to Tredgold's rules, all dimensions for other scarfs may be reasoned out in a similar manner.

$a\ c$ = sum of the depths of indents = $\frac{\text{depth of beam}}{3}$

$c\ b$ = for practical purposes = $a\ c$.

$c\ d$ = the ratio of resistance to detrusion is to the direct cohesion = $\left\{ \begin{array}{l} \text{Oak, ash, elm, 8 to 10 times } c\ b. \\ \text{Fir or straight-grained woods, 16 to 20 times } c\ b. \end{array} \right.$

The length of scarfs should bear the following proportions to the depth:—

	Without bolts.	With bolts.	Bolts and indents combined.
Hard wood (oak, ash, elm)	6	3	2
Fir and straight grained woods ..	12	6	4

If assisted by fish-plates it may be equal to the strength of a simple fished joint, which is as strong as the tie itself, less one rivet hole, and no advantage is gained by making the joint complicated, but should be formed similar to that shown in figure 175.

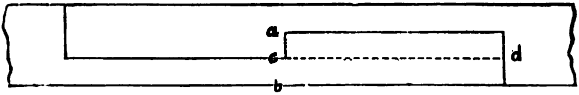


Fig. 171.

Figures 172 to 174 show three forms of joints to resist tensional strain. Figure 172 at A and G shows splayed sallys. These are made, as they assist in keeping the joint from shifting laterally. This joint is not recommended, as it has to be made very long, or it will be weak along the line CD.

Figure 173 shows a scarf constructed by tabling and tongue formed at ends, secured by hard wood keys or wedges.

Figure 174 shows a simple form of scarf, tightened up by wedged keys. Seddon recommends the shearing area along BF to be at least six and a half times BC, and BC should equal twice the depth of the key.

Scarfs to resist Compression.—For joints to resist compression, the abutting surfaces should be perpendicular to pressure, consequently all shoulders should be square, and no splayed sallys should be allowed. The following are suitable:—Scarfs similar to those shown in figures 173 and 174, but with shoulders square, as at A, figure 179, and the method shown in figure 175, formed by halving, iron plates and bolts. The example as shown in figure 176, though sometimes adopted, is not to be recommended, as the abutment is not perpendicular to

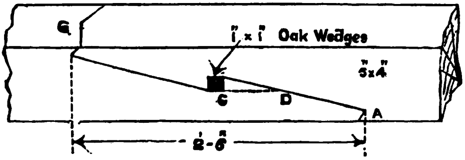


Fig. 172.

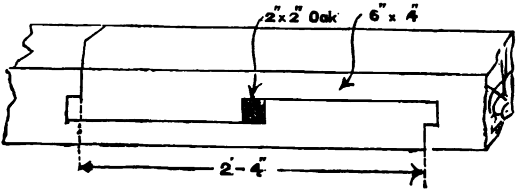


Fig. 173.

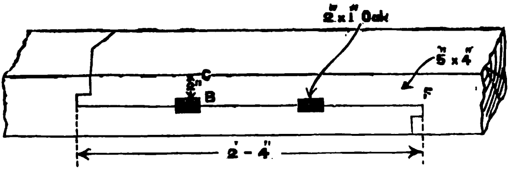


Fig. 174.

the pressure. It is better to have the ends of scarfs tongued, as in figures 173 and 174, as it helps to keep the joint in proper position if care is taken to have all the shoulders hard up.

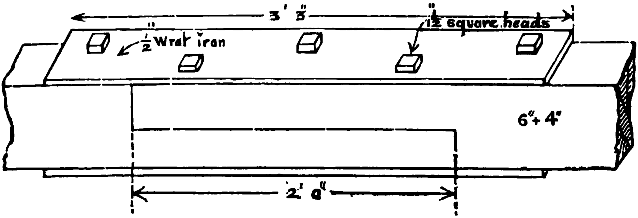


Fig. 175.

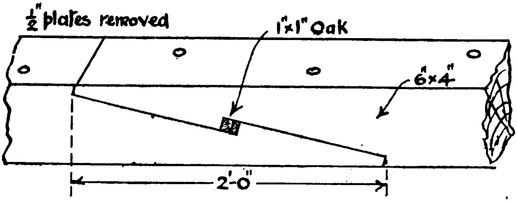


Fig. 176.

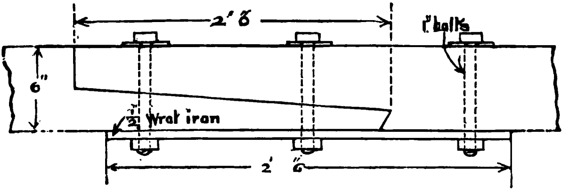


Fig. 177.

Cross Strain.—The method, as illustrated in figure 177, is employed when the timber is under a cross stress. A square shoulder is formed in the upper fibres, as they are under a compressional stress; and the lower fibres being in tension are connected with a wrought iron plate, the sally may be splayed as it is easier to fit, and the iron plate bolted on, the efficiency of which determines the strength of the lower side.

Cross Strain and Tension.—Figure 178 shows a scarf tabled so that the strength may not depend wholly on fastenings.

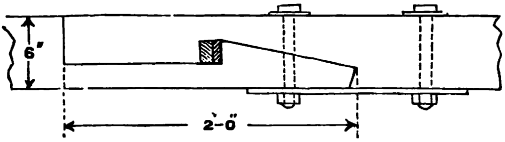


Fig. 178.

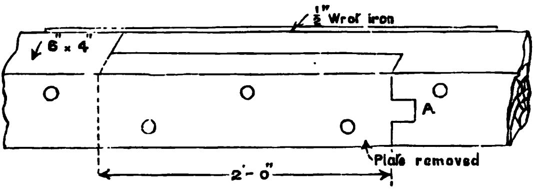


Fig. 179.

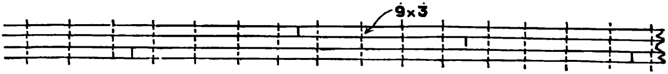


Fig. 180,

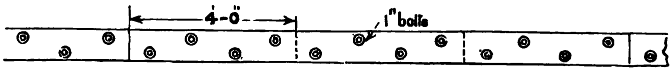


Fig. 181.

Figure 179 shows a beam scarfed vertically through its depth, and tongued at ends, as shown at A, and appears better adapted than any other to resist cross strain and tension.

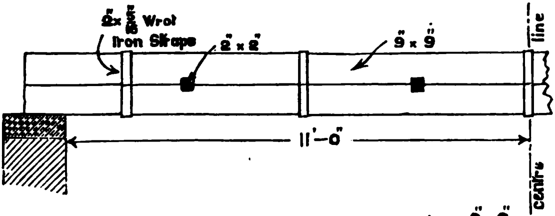
Building up.—For temporary structures beams may be economically built up as shown in plan and elevation figures 180 and 181.

Figure 182 shows another method of building up by laying one piece on top of another, and preventing same from sliding by bolting or strapping and hard wood keys.

Figure 183 shows a method of preventing sliding, by forming indents, the sum of which should equal $\frac{2}{3}$ depth of beam, and be secured by iron straps.

Notching.—Joists resting on wall plates are commonly notched for the purpose of bringing all the upper surfaces of joists of irregular depth to the same level as shown in figure 184, besides which the shoulder assists in keeping the work square, and if the end projects, as in figure 185, forms a tie.

Fig. 182.



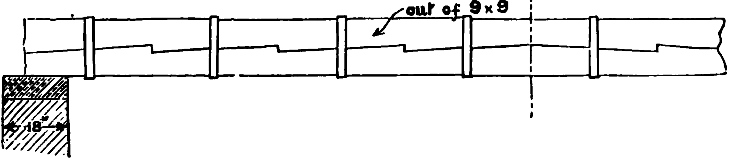


Fig. 183.

Cogging.—When wall plates, purlins, rafters, or other timbers have timbers crossing them and it is desired to have the entire bearing depth of timber, and to tie the lower, other than by the fastenings which often consist only of spikes, the pieces may be cut and fitted as in figure 187, two cheeks of rectangular section being taken out of lower piece, and the upper member having a sinking to correspond to the projection left on lower piece; this method is called cogging. Where the end of the joist does not project over plate it is advisable to form the cog on edge of plate, as in figure 186, to obtain the greatest amount of shearing area behind the cog, as the section of bearing surface has usually an excess of strength.

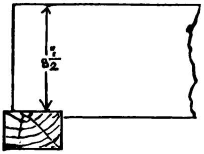


Fig. 184.

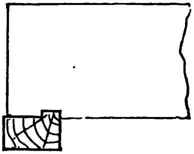


Fig. 186.

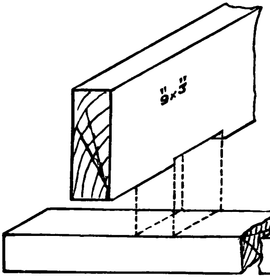


Fig. 185.

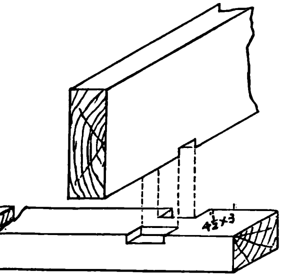


Fig. 187.

Halving.—Timbers that cross each other, and are required to be flush on one or two faces, and have a similar sinking in both to fit each other, are said to be halved together, and may be cut as ordinary, bevclled, or dove-tailed halving.

1st. Ordinary halving, as in figures 188 and 189, suitable for wall plates or braces of partitions crossing each other.

2nd. Bevelled halving, which assists in holding pieces together when spiked, as shown in figures 190 and 191.

3rd. Dove-tailed halving is used where one member is to act as a tie, such as a collar beam for roofs, and ties for wall plates, as in figure 192; but as the dovetails are usually made of great width in carpentry the pieces shrink, and the joint becomes loose, and fails for the purpose for which it was intended.

Fig. 188.

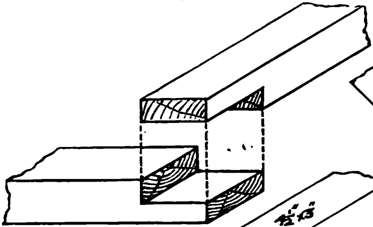
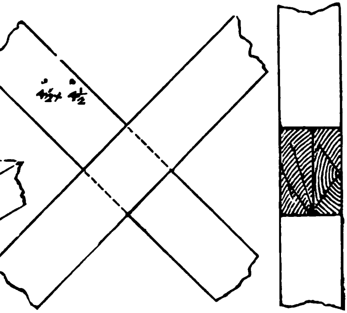


Fig. 189.



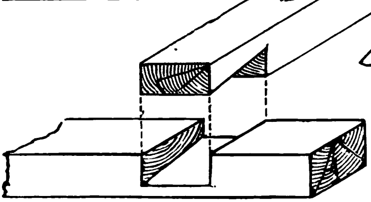


Fig. 190.

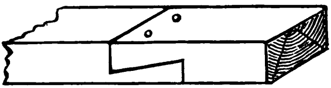


Fig. 191.

Housing.—When the entire end of a piece of timber butts and fits into another piece, it is said to be housed, and is used for heavy work, or where other methods would be weak or expensive. The pieces joined would be secured by bolts, straps, wedges, or other fastenings.

Mortice and Tenon.—For simplicity of construction and efficiency for its purpose, the mortice and tenon joint is pre-eminently good; and is, undoubtedly, used in some form or other more than any other kind of joint.

Ordinary Mortice and Tenons.—The end of a piece of timber is cut so that a projection or tenon is formed which has a thickness ⅓ that of the material, the adjoining piece is mortised to correspond to the tenon, and may be secured either by wedges from the back, as in figure 193, by dowel pins from the faces, as in figure 391,

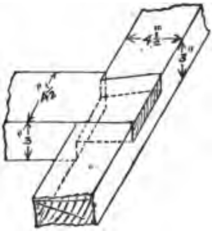


Fig. 192,

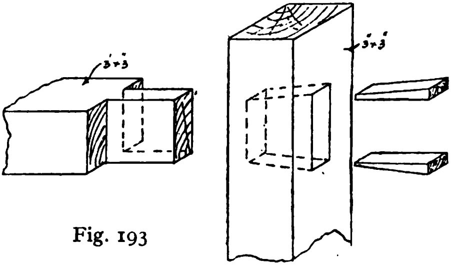


Fig. 193

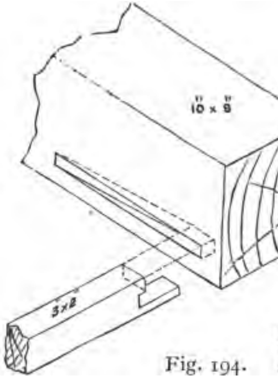


Fig. 194.

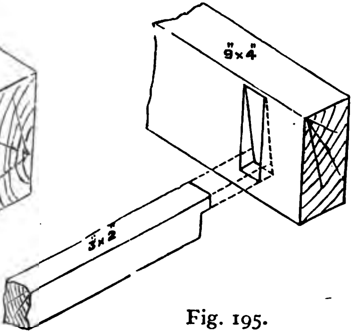


Fig. 195.

or wedges and dowels may be combined for purposes of strength.

Chase Mortices.—Wherever it is required to fix timbers between the main timbers which are already secured and immovable. the method of chase mortising may be adopted, which consists in fitting one end in the ordinary manner, and in the other main timber the mortice to receive the other extremity is cut, as illustrated in figure 194, to allow the tenoned member to revolve into its ultimate position, the end fitting into the ordinary mortised main, timber being used as centre. The same purpose may be accomplished by cutting a vertical groove, as in figure 195, to allow the tenoned member to drop into its place; but by this method fibres are cut, which are not necessarily severed for the mortice, and so its strength is reduced. The better system is to make the horizontal chase, which has the advantage of not necessarily reducing its tensile strength. Ceiling joists in double and double framed floors are very extensively fixed in this manner, and instead of cutting away a triangular piece for each joist, a rectangular groove in plan is cut between mortices in every other space between the joists.

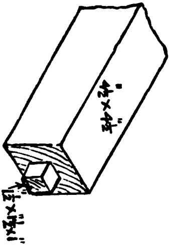


Fig. 196.

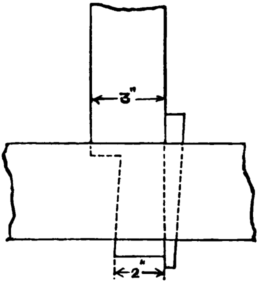


Fig. 197.

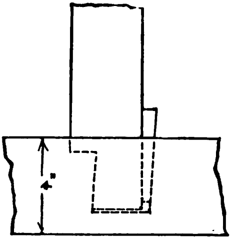


Fig. 198.

Joggle, Stuh, or Stub Tenon.—Is the name given to a short tenon, and is more particularly known as a joggle when cut, as shown in figure 196, which is used to prevent the foot of a post sliding away from its sill.

Tenoned and House Joints.—For purposes of bearing strength where the ordinary tenon might not be sufficient, the rail is housed a short distance into the post or style, and tenoned in the usual manner. Figure 268 shows this joint, and the shoulders pulled closely together by means of a key.

Dove-tailed Tenon.—Where two pieces are required to be held together by a mortice and tenon, and to be taken apart occasionally, the tenon may be cut dovetail shape and the mortice made long enough to permit the wide part of tenon passing through, and when in this position it is secured by a hard wood wedge as in figure 197. This method may be adapted to secure pieces together, as shown in figure 198, when the back edge is not to be cut or is inaccessible.

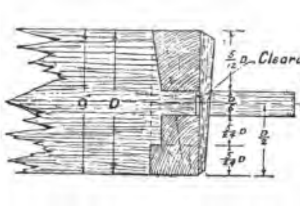


Fig. 199.

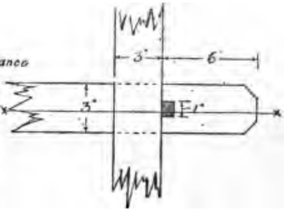


Fig 200.

Tusk Tenon.—Where floor timbers of equal depth are framed into each other it is desirable that the loss of strength should be reduced as much as possible, and yet the members joined must be securely held together. The best bearing joint complying with these conditions is the tusk-tenoned joint. The tenon should be placed in the centre of the depth of the pieces joined for two reasons. First, when it is in that position the stress caused by driving the wedge draws up both top and bottom shoulders equally tight. Secondly, the best position for the mortice is theoretically in the compressional fibres immediately adjoining the neutral layer, and in good specimens of northern pine timber beams, supported at

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both ends under loads, this layer is three-eighths the depth from the bottom, and consequently five-eighths of the depth from the top; this is due to the resistance of compressional to tensional stress being in good quality fir or pine timber, in the ratio of three to five, and thus causing the neutral layer in a rectangular beam to be in the position stated, but as any knots or defects in timber would affect the tensional fibres more than the compressional, it is safer to place the centre of the tenon in the centre of the depth, which will be found in practice quite sufficient, and to make the tenon $\frac{\text{depth}}{6}$. The underside of the tenon will then be $\frac{D}{24}$ above the theoretical neutral layer of a good specimen, and most probably exactly above in an average quality timber. The depth of the tusk may be $\frac{5}{24}D$ of the depth, that is one half of the distance between the under surfaces of tenon and joist, as shown in figure 199.

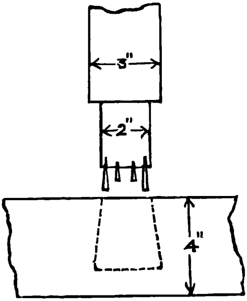

Fig. 201.

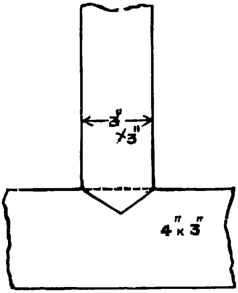

Fig. 202.

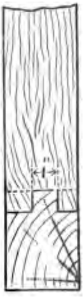

Fig. 203

In cases similar to binders tusk tenoned to large girders, especially wherever the tenons of two binders are arranged exactly opposite, the tenons of the former do not pass through the entire section of the latter, but only penetrate 3 or 4 inches, and are then spiked with large iron nails or secured with oak dowel pins or trenails, always aiming to reduce the section of the main timber as little as possible.

Foxtail Wedging.—Is a method of securing timbers where the back edge of mortised timber is either not to be cut or inaccessible, as in the example of a rail to be secured to a post already fixed against a wall. The tenon may be cut with a fine saw, and small hard-wood wedges inserted, the longest ones outside, and the mortice in post is cut with splayed sides, as in figure 201, so that when the rail is driven hard against its shoulders, the tenon assumes a dove-tailed form. This joint, when properly made, has this advantage over the ordinary method, that the post or style shrinks towards the shoulder and not away from it, and for this reason is sometimes employed for first-class joinery work.

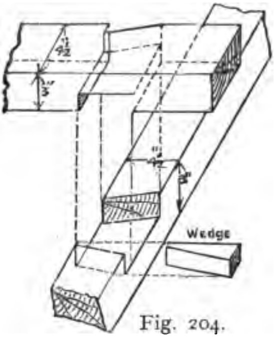

Fig. 204.

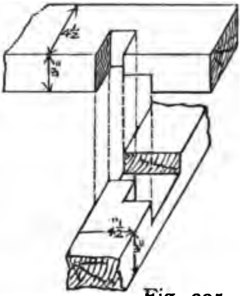

Fig. 205.

Bridle Joint.—Is the name given to that joint, as shown in figures 202 and 203, that has its mortice or slot on the member that would be tenoned in the ordinary method, and the piece on which a sunk tenon is formed would in the usual joint be mortised. It is more expensive to make, but some architects prefer it to the mortice and tenon joint, as any bad workmanship can be easily detected, and if it is cut with a little care the centre of pressure is more likely to coincide with the axis of the strut.

Dovetailed Notch.—This joint is a combination of dovetailing and notching, to overcome the weakness of the dovetailed halving. The lower timber is cut to admit of a wedge, which driven with great force crushes the fibres closely together in their width, and so reduces the possible shrinkage. The end is left projecting, as in figure 204.

Tredgold's Notch.—Figure 205 shows a method recommended by Tredgold as being superior to the dovetailed notch, but is more expensive to make, and the advantage obtained is not sufficient to justify the extra cost.

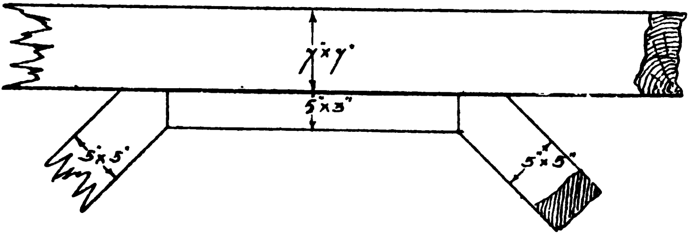

Fig. 206.

Strut and Beam Joints.—Where struts are used to strengthen horizontal beams or shores, a straining piece is usually fixed to the beam and the ends of the struts cut as shown in figure 206. Where the horizontal member is short the straining piece is dispensed with and the ends of the struts are butted.

Joints for Struts and Ties.—These may be constructed as follows:—

(*a*). With oblique tenons which would be liable to shear, as in figure 207, or assisted by plate bolted to tie, as shown in figure 208.

(*b*). By inserting a piece in grooves cut in rafter and tie beam, to prevent sliding, as in figure 209.

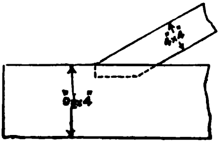

Fig. 207.

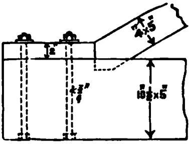

Fig. 208.

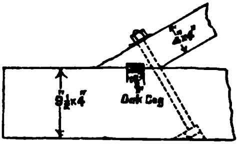

Fig. 209.

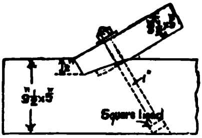

Fig. 210.

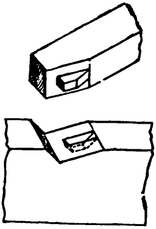

Fig. 211.

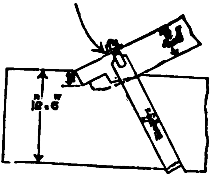

Fig. 212.

(*c*). With single abutment and tenon, as shown in figures 210 and 211. This is simple, effective, and generally used when there is sufficient length of tie behind strut to resist shearing strain.

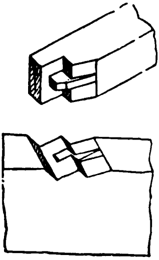

Fig. 213.

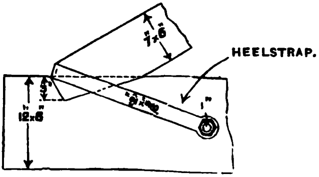

Fig. 214.

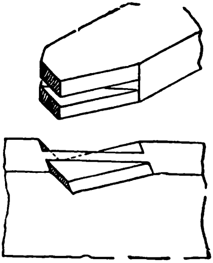

Fig. 215.

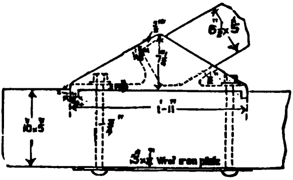

Fig. 216.

(*d*). With double abutment when length behind the strut is very short, to prevent the tie-beam shearing, as in figures 212 and 213.

(*e*) *Bridle Joint.*—This is a method employed to increase the shearing area; it is especially applicable to such work as shown in figures 214 and 215, where the length of tie in front of strut to resist the thrust is small. In addition to having a large shearing area, it has the advantage that any defect in the fitting would be apparent.

(*f*). *Cast Iron Shoes.*—To prevent tie shearing, and to secure the oot of strut, a cast iron shoe is constructed to receive foot of strut and with flanges which are bolted to the tie-beam, as shown in figure 216.

Fastenings.—Joints in carpentry should have white-lead applied with a brush over the surface forming the joint, and may be secured in their positions by the following fastenings:—

1. Pins
   - Wood Pins.
   - Nails.
   - Bolts.
2. Wedges.
3. Straps.
4. Sockets.

Pins.—These may be of wood or iron and may be sub-divided as dowel pins, trenails, spikes, dogs, screws, and bolts.

Dowel Pins.—When boards are required to be kept in the same plane surfaces, and yet not to resist the shrinkage of the wood, dowels out of oak or hard wood of straight grain and split to the diameter required, and not cut with the saw, so that none of the fibres are cut across, and slightly tapering in their length, are employed as in the example of flooring, figures 234 and 235. Dowels are used to fix mortice and tenon joints and are especially applicable for large or triangular framing to pull the shoulders tightly up, which method is called drawboring, which consists of boring through mortised piece, then marking tenoned member and boring same, not exactly in the mark, but towards outside corner of shoulder, which has the effect, when dowel is driven with great force, of bringing shoulder up closely.

Trenails.—Hard wood pins of large diameter are called trenails, and are extensively used in shipbuilding or in positions where iron fastenings would be liable to rust.

Spikes.—Are iron nails above three inches in length extensively used in fixing timbers together. They require to be hammered in with great force. Spiking is a cheap method of fixing.

Screws.—These are used instead of nails where any vibration in fixing would be objectionable, or where pieces are required to be taken apart occasionally, as in figure 420.

Bolts.—Wrot iron bolts and coach screws are used where spikes or screws would not offer sufficient tensile resistance. The bolts are screwed at one end for a tapped nut to fit on, and to prevent nut and head sinking into timber when tightened up, are supplied with wrought iron washers, which, against oak, should be two and a half times diameter of bolt, and for fir, three and a half times.

Dogs.—Are pieces of flat or round wrought iron bent at ends, which are pointed and hammered in to secure timbers that butt against each other, especially used in shoring, rough stagings, and temporary structures.

Wedges.—Are pieces of wood cut taper to secure joints together, as in the mortice and tenon joint; when used in pairs as for scarfs which draw up more equally are called folding wedges.

Keys.—Is the name given to hard wood wedges, especially used to pull joints closely together as in tusk tenon joint, figure 199.

Straps.—Are fastenings formed of metal bands, usually wrot iron, to enclose timbers together and keep them in the required positions, and may have ends forged and screwed which pass through bearing-plates, to which they are secured, as in figure 212, or may be drawn up by gibs and cotters, as illustrated in figures 281 and 282, or may simply form a stirrup or heel-strap, and be secured by a bolt, as in figure 214, where it is used to prevent the end of the tie-beam being sheared.

The advantage of straps over bolts is that they need not cut into the timbers joined.

Tredgold's rules for straps are as follows:—

10 ft.	span	the	strap	may be	1	in.	wide by	$\frac{3}{16}$ths in. thick.
15	,,	,,	,,	,,	1½	,,	,,	¼ ,,
20	,,	,,	,,	,,	2	,,	,,	¼ ,,

Sockets.—Are made of cast iron to enclose the ends of timbers to prevent it splitting, and to retain the pieces in the required position, as in figure 292. When used at the feet of members they are called shoes, as in figure 216.

CHAPTER VI.

FLOORS.

The tiers or levels which divide a building into stages or stories are called floors, and for residential purposes are mostly made of timber and may be divided under three heads.

Single-joisted Floors.—Include bridging joists.

Double-joisted Floors.—Include bridging joists supported by binders.

Framed Floors.—Include bridging joists supported by binders, the latter usually being framed into girders which finally support the load.

Single Floors.—When the total weight upon a floor is carried by a single system of joists, which span or bridge an opening, it is called a single floor, and the joists are known as bridging joists, and are usually fixed twelve inches to fifteen inches apart between the centres; and although the simplest construction, with the same quantity of timber it forms the strongest floor. To these joists laths may be nailed to receive the plaster, or ceiling joists are attached, crossing at right angles the bridging joists, to which the lath and plaster is attached. It is usual to arrange the bridging joists in the direction that has the least span between supports.

Scantling for bridging joists of northern pine, distance apart from centre to centre twelve inches.—From Tredgold's "Carpentry."

Clear span in ft.	Dimensions in inches.	Clear span in ft.	Dimensions in inches.
5	5¼ × 2 or 4⅜ × 3	14	10 × 2 or 9 × 3
6	5¾ × 2 ,, 5 × 3	16	11 × 2 ,, 9¾ × 3
8	7 × 2 ,, 6¼ × 3	18	12 × 2 ,, 10½ × 3
10	8 × 2 ,, 7 × 3	20	12 × 2½ ,, 11 × 3¼
12	9½ × 2 ,, 8 × 3		

Basement Floors.—Under the basement floors of houses thin walls are built generally about 6 feet apart, to carry sleeper plates, to which the joists are fixed. The nearer the sleeper walls are constructed, the less will be the scantling of joists required. Figure 217 gives a section through a sleeper wall.

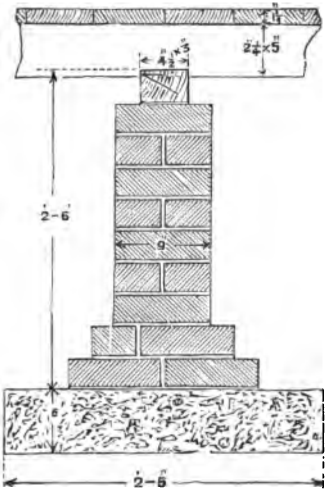

Fig. 217.

Upper Floors. — Floors above the basement are constructed with trimmed openings to form well holes for staircases, lifts, trapdoors, and to clear flues, in order that no woodwork may penetrate walls nearer than nine inches to the flue, and no wall plate or joist may be within a distance of two inches from a flue wall four and a half inches thick without it is rendered in cement.

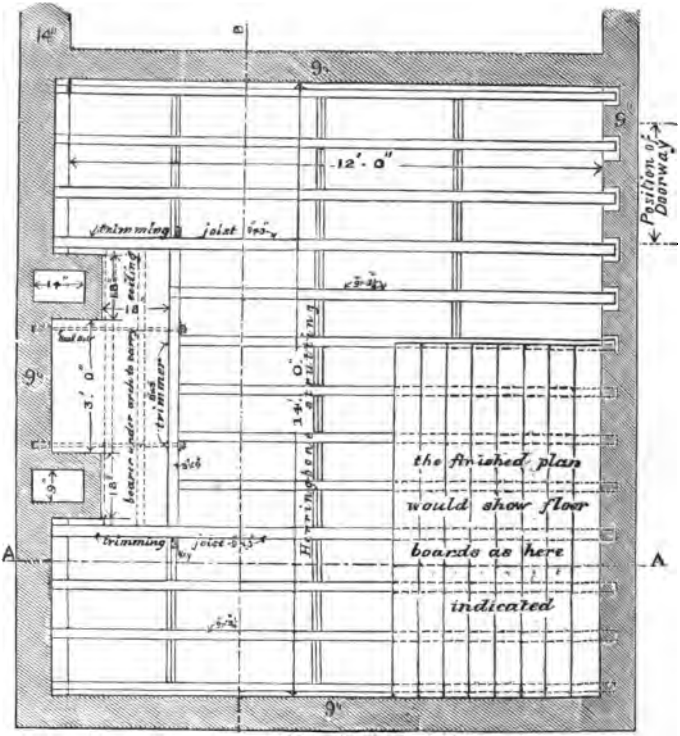

Fig. 218.

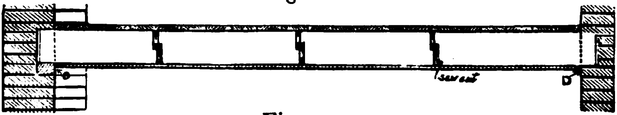

Fig. 219.

Figure 218 shows the trimming to clear flues in chimney breasts, the joists being arranged in the shortest direction; this necessitates two trimming joists and one trimmer, which is carrying the ends of five trimmed joists. All the joints between trimmed, trimmer, and trimming joists are tusk tenoned, as described on page 74, to have great bearing strength. To obtain 18 inches of fireproof material, 7 inches thick, in front of fireplace, a coach head trimmer arch is turned, as shown in figure 221, which may extend from trimming joist to trimming joist, and never less than 9 inches on each breast, over which is a bedding of concrete, and back and front hearths of York stone 2½ inches thick. Sometimes back and front hearths are in one piece, and are usually 18 inches longer than openings. The floor is stiffened with herring bone strutting, the rows of which should not be more than 4 feet apart.

Section through Fireplace.—Figure 221 gives section which shows method of forming rough coach head trimmer arch, with wood springing piece nailed to trimmer. The ceiling underneath is upheld by small joists resting on fillets 1½ inches by ¾ inch, nailed to trimming joists; or the ribs used as the temporary centre of the arch are allowed to remain to answer that purpose.

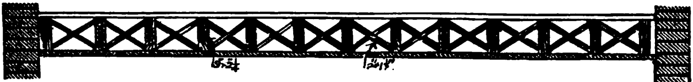
Fig. 220.

In wide chimney breasts the arch is sometimes stopped before it reaches the trimming joists, on which a shaped piece of joist timber may be fixed to the back of the arch, provided it is 9 inches away from opening, to which the floor boards are secured. Sometimes a short joist is placed against end of arch, tusk tenoned into trimmer, the other end resting on iron bar or corbel which is driven into brickwork.

When the plan of floor shows a trimming joist instead of trimmer forming abutment of arch, as in figure 222, two hook bolts should be used between the flues, to prevent the arch failing by the trimming joist bending, as shown by dotted lines, figures 221 and 222.

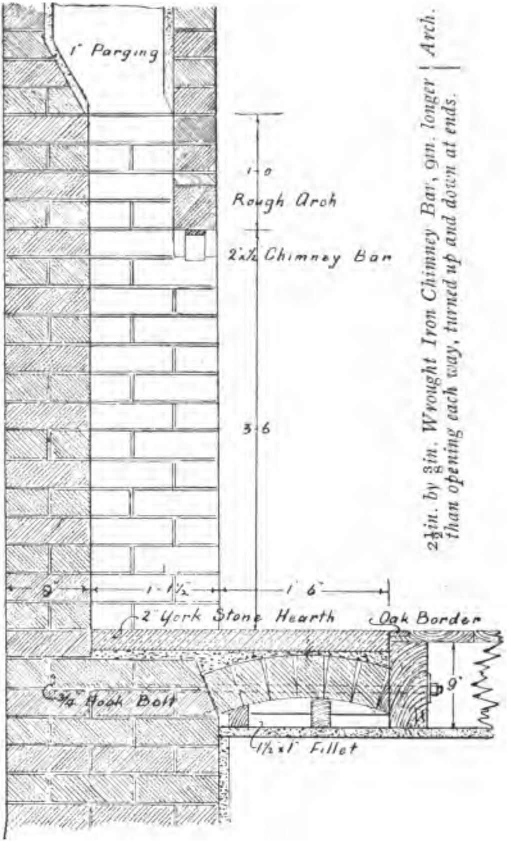

Fig. 221.

Figure 222 gives the outline plan of floor arranged with bridging joists laid in the shortest direction, and as flues are in the same direction there will be only one trimming joist, and that is parallel to the width of chimney opening, and two short trimmers carrying the trimmed joists. This method requires less timber and labour than those laid in the opposite direction, as described on page 84.

Methods of carrying Joists and Wall Plates.—Joists may rest directly on walls or be fixed to wall plates; and the latter may be carried by walls or projections from walls as follows:—

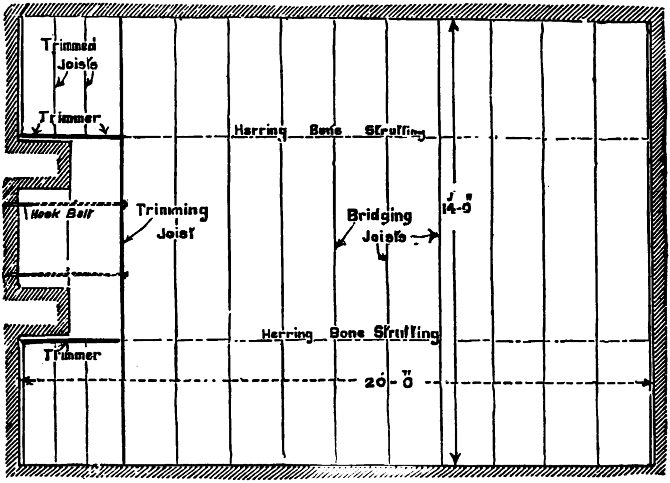

Fig. 222.

1st. Joists may simply rest on, and be spiked to wall plate, which rests on a brick wall set off to carry same, as is usual in the lowest floor of a house, as in figure 223.

2nd. Joists may be notched on wall plate, the walls being corbelled out to carry wall plates, as in figures 106 and 107. This is not recommended, as bricks are not usually a very good material to resist sudden shocks.

3rd. Joists may be cogged on wall plate, supported by stone corbels at intervals, as in figure 224, and are subject in a lesser degree to the same objection as brick corbels.

4th.—Joists may be notched on wall plate which is built in wall, as shown at C, figure 219; but as the latter in this position would act as a bond timber, is subject to dry rot, and to become loose; and if at any time it is destroyed by fire, the section of the wall is reduced at a very critical moment.

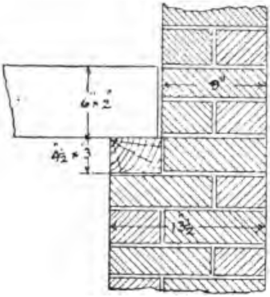

Fig. 223.

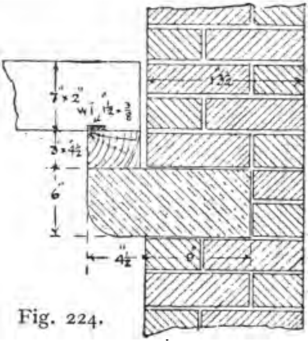

Fig. 224.

5th. Joists may simply be built into wall, as shown at D, figure 219; but direct contact with brickwork is not advisable, as all surfaces in contact would be subject to dry rot.

6th. A cheap and strong method extensively used for thin walls that must not be reduced in section, is to secure the joists to wall plates which are carried by wrought iron corbels, 4 inches wide, ½ inch thick, built into walls, as in figure 225.

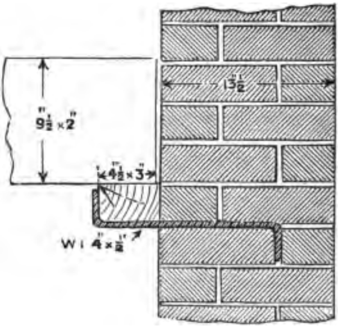

Fig. 225.

7th. The best method in thin walls is to build in, a 2 inches by ⅜ inch wrought iron bearing bar on brickwork, with the ends of joists resting on same; this arrangement distributes the pressure, and is not subject to the objection urged against bond timbers. Always construct pockets in brickwork large enough to form a space of at least ½ inch clearance at ends of joists, as shown in section and elevation, figures 226 and 227, to prevent dry rot.

Trimming.—Is the method of arranging timbers to distribute the weight of bridging joists that are stopped short to form openings, clear flues, or form well holes. The timbers cut short are called trimmed joists, and those which carry their ends and distribute their weight on to walls or other timbers are known as trimmers; and the joists that carry the ends of trimmers are the trimming joists which are usually parallel to the ordinary bridging joists, as shown in figures 218 and 222.

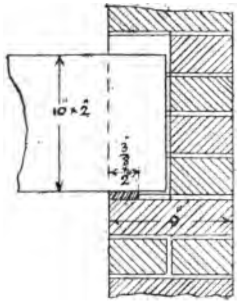

Fig. 226.

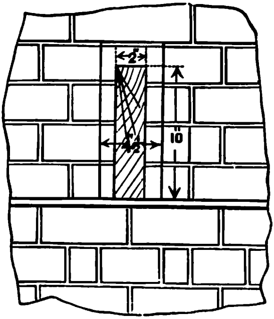

Fig. 227.

Tredgold recommends the trimming joists to be ⅛ inch wider for every trimmed joist carried when the depth of timbers are the same, and the trimmers to be calculated as binders. In practice the trimmers are of the same scantling as trimming joists.

Strutting.—Joists laid with boards on top, and lath and plaster underneath, are found to be insufficient to prevent bending and vibration under pressure. To remedy this, which is injurious to the walls and to the timber members, strutting is placed in straight continuous rows, at intervals not more than 4 feet apart, which reduces to a great extent the defect.

The following are three methods of strutting:—

Herring Bone Strutting.—Consists of pieces about 2 inches square, fixed as shown in figure 243. It is usual instead of boring for nails to make a saw cut at ends, and through this channel to drive the nail. By doing this any danger of splitting is avoided. This method has the recommendation, that it acts where its leverage to prevent bending is greatest, viz.: at the edges of joists, and is used largely in dwelling-houses.

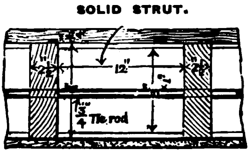

Fig. 228.

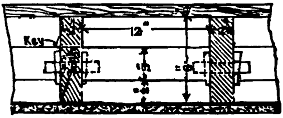

Fig. 229.

Solid Strutting.—One inch or 1¼ inch boards, nearly same depth as joists are cut in tightly, and nailed between joists, as in figure 228. This method is greatly used for floors of factories and heavy buildings; and if cut, so that its entire shoulder butts against the joists, is undoubtedly the firmest method; but without care is exercised the shoulders are apt to bite on the centre only. Sometimes long bolts, either of round bar iron or gas pipe, are passed through all the joists, and the strutting crushed together with the joists and held tightly.

Key Strutting.—When the arrangement of fixing tenoned pieces mortised in joists, and secured by keys is adopted, as shown in figure 229, it is known as key strutting. This construction is expensive, weakens the joists and is not so effective as the previous methods, as the rows are not continuous, and therefore is rarely used in floors.

Joints of Flooring.—The following are the general methods of arranging the longitudinal joints of flooring (which may be drawn together by means of special cramps called dogs), and may be divided into two classes as follows :—

(*a*) Joints with visible fixing, as plain, ploughed and tongued, rebated, and rebated and filleted joints.

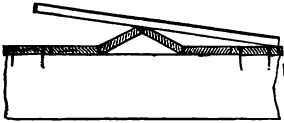
Fig. 230.

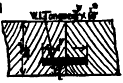
Fig. 231.

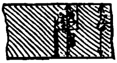
Fig. 232.

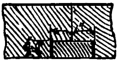
Fig. 233.

(*b*) Joints with secret fixing, as dowel, rebated, grooved and tongued, twice ditto, and splayed ditto joints. and these may be again sub-divided into joints, which do and do not admit of dust passing through when boards have shrunk.

Plain or Square Joint Laid Folding.—Square joints are forced together, where iron cramps are not obtainable, in the following manner :—About six battens are taken and laid into position ; one outside is fixed and the others are pushed together, and the boundary marked. The loose outside batten is now fixed ⅜ inch nearer to the board already fixed, and the others are placed, as shown in figure 230, with a plank across them, on which two or three men jump. This crushes the boards together, and closely fitting joints are obtained, and while kept in this position they are nailed to the joists.

Ploughed and Tongued.—A groove is made on each edge of board lower than the centre, so as to obtain as much wear as possible, and a wood or iron tongue is inserted which prevents edges curling up and any dust passing through, as shown in figure 231.

Rebated Joint.—For floors this joint has no special advantages to compensate for its extra expense, and is a construction not much used. It prevents dust passing through, as shown in figure 232.

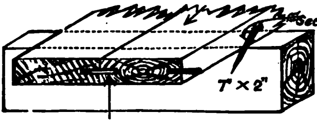

Fig. 234.

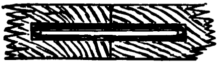

Fig. 235.

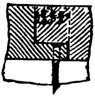

Fig. 236.

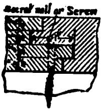

Fig. 237.

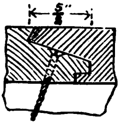

Fig. 238.

Rebated and Filleted.—The advantages of this method, as shown in figure 233, is that the greater part of the depth can be worn before the fillet is exposed, and is used in barracks and similar places where floors undergo heavy wear.

Secret Joints.—Important or polished floors are often required to be secured in such a manner as not to show their fixing, or present gaps, or unsightly holes, as would occur in ordinarily fixed flooring; and should be free to shrink or swell without splitting, which is accomplished by fixing on one edge only. Figures 234 and 235 show a cheap and effective method, the boards being secured by dowel pins, and screwed to joists through one edge only; but to prevent dust passing through, ploughed and tongued joints should be used in combination.

Figures 236 and 237 show the methods by rebate, groove and tongue, secured by screws on one edge only. These can be easily fixed or taken up when required, and also prevent any dust passing through. The expense of these joints is the great objection to their general use. The method shown in figure 238 possesses the advantages of the two preceding joists at a much less cost.

Heading Joints.—The joints between the ends of floor-boards are called heading joints, and may be square, splayed, or forked.

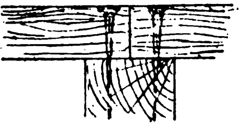

Fig. 239.

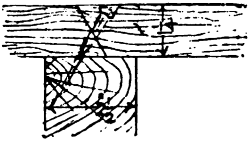

Fig. 240.

Square Heading Joints.—These are usually secured by two nails on each side of joint, as in figure 239.

Splayed Heading.—When the ends of boards are bevelled; only one board need be nailed, as in figure 240, and the splayed heading will effectually secure the end of adjoining board. This is the method usually adopted.

Forked Headings.—These headings are made with a series of triangular forks, which fit into each other, as in figure 241. It is very expensive to make, and is only used in very good work.

Secret Headings.—These may be formed in a similar manner to the joints shown in cross section, figures 235 to 238.

Straight Joints.—This is the name given where the heading joints of adjoining boards are arranged on the same joist; such work looks unworkmanlike, as the plan of all heading joints should present a bonding appearance.

Broken Joints.—In old-fashioned floors, before the extensive use of machinery for joiners' work, boards of different widths were used, and it often happened that boards were laid, as shown in figure 242. The interrupted longitudinal joint is then said to be broken.

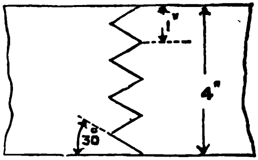

Fig. 241.

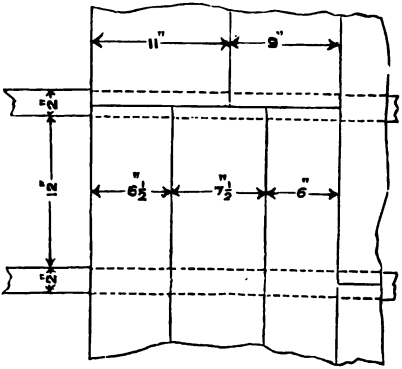

Fig. 242.

Prevention of Sound.—To prevent the passage of sound between rooms of adjoining levels, the following methods may be adopted:—

First.—By reducing the number of through timbers the continuity of transmission is interrupted which lessens the sound; every fourth or fifth joist being made deeper than the others, to these the ceiling joists are secured, as shown in figure 243.

Secondly.—The most effective consists of a double system of joists, each system being entirely separate, and not connected in any part. With this system no sound can be carried by conduction, and if all the members are bedded on felt, and the bridging joists strutted, as shown in figure, the passage of sound would be reduced to the minimum.

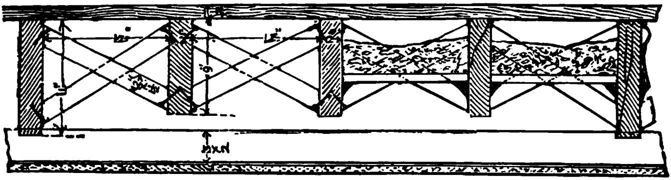

Fig. 243.

Thirdly.—Layers of list or felt are placed under every bearing of girders, binders, bridging joists, and floor boards, to reduce vibration and sound.

Fourthly.—Various methods of pugging are used to prevent the passage of sound, the object being to deaden the sound waves. They are never quite successful in preventing the passage of sound, and are objectionable as they induce dry rot in the timber, and the circulation of air is often impeded, if not entirely stopped, if the pugging is not near the top or bottom of the joists.

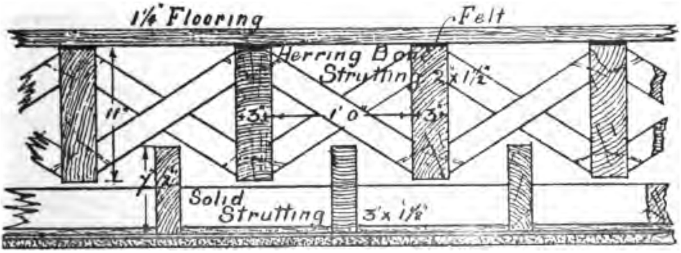

Fig. 243a.

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The pugging employed may consist of coarse plaster, slabs of coke breeze, concrete, layers of slag wool, or slabs of fibrous plaster.

The fibrous plaster slabs are sometimes placed on the top of the joists, the entire floor space being covered with felt immediately beneath the boarding in order to deaden the sound. This is effective in reducing the sound, but does not protect the lower portion of the joists from fire. The better plan is to place the plaster slabs as close to the ceiling as possible, and have the tops of the joists only covered with felt. The flames would have a much smaller space to play upon, and the floor could be strutted and ventilated in the usual way.

Ceiling Joists.—The small joists that carry the lath and plaster ceiling only, and are suspended to other timbers, are called ceiling joists. The usual dimensions are 3 inches × 2 inches, as smaller pieces might be split by the nails, and are fixed about 12 inches apart, and may be secured to the upper timbers by simply spiking, chase mortising or notching over fillets planted on sides to receive them, as in figures 246 and 247.

If $\frac{1}{2}$-inch is multiplied by the number of feet spanned by ceiling joists 2 inches thick, it will give the necessary depth.

Lathing.—Laths are fixed slightly apart to the under side of joists, the opening and space in rear allowing the plaster to pass through and protrude, thus affording a key for the plaster; and, therefore, should never be fixed on wide joists, as the key would be interrupted. Laths should be fitted with a butted and not a lapped joint.

Brandering.—If the joists are made thicker than

2 inches, to obtain the necessary key for plastering, fillets one inch square may be fixed to their underside, to which laths may be nailed; this method is called brandering.

Double Floors.—Consist of bridging joists and binders, with or without ceiling joists, and are used where the supporting walls are perforated with openings, so that the weight may be taken by columns, piers, or the uninterrupted parts of walls which are arranged to receive them. The binders stiffen the floors, and, for reasons explained in page 94, decrease the sound passing from room to room if ceiling joists be used.

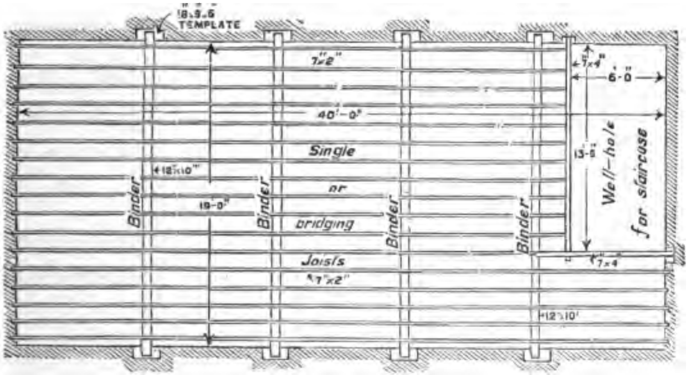


Fig. 244.

Figure 244 gives the plan of a double floor, the binders resting on stone templates built into walls. Ceiling joists, if any, are usually immediately under the bridging joist.

Scantling for binding joists of northern pine, distance apart from centre to centre, 6 feet, from Tredgold's Carpentry.

Clear span in feet.	Dimensions in inches.	Clear span in feet.	Dimensions in inches.
10	8 × 8	16	11 × 7¾
12	9 × 8	18	12 × 7½
14	10 × 8	20	12 × 9½

Double Floor Sections.—Figures 245 to 247 show ordinary methods of arranging binders to carry floor and ceiling joists. Where the extra height obtained is considered a greater advantage than efficiency of sound resistance, the lath and plaster ceiling may be attached to the bridging joists. The binder may be worked as illustrated in figure 245, which gives the ceiling a panelled appearance. Where the projection of binder in lower room is an objection, the bridging joists are often housed a great portion

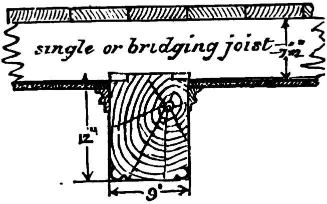


Fig. 245.

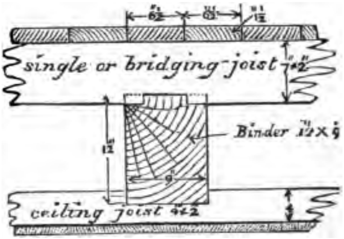


Fig. 246.

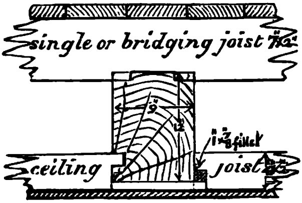


Fig. 247.

of their depth and notched over the binders, but the extra cutting required will somewhat weaken the binders.

Wrought Iron and Steel Binders.—Rolled iron and steel joists are now extensively used as binders, the upper flange of which may support the floor joists, and the lower flange the ceiling joists, as in figure 248.

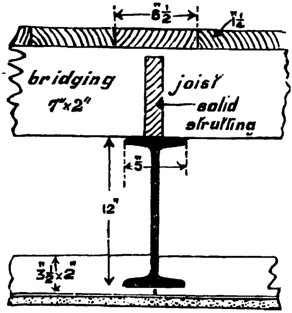


Fig. 248.

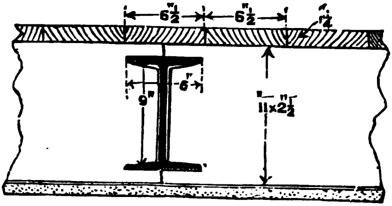
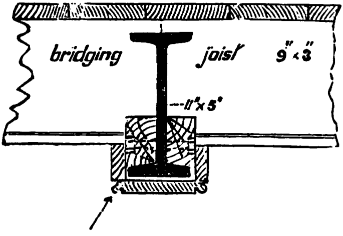
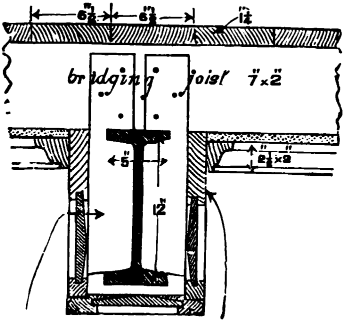


Fig. 249.



1in. beaded casing

Fig. 250.



1½in. deal packing pieces 1¼in. framing.

Fig. 251.

When the depth of the floor is required to be as shallow as possible, such joists for binders are useful, as the floor may be constructed without increasing the depth required by the bridging joists, as shown in figure 249.

Figures 250 and 251 show two methods of rolled iron or steel joists used as binders, to give the ceiling a panelled appearance.

Framed Floors.—Are composed of bridging joists, binders, and girders, with or without ceiling joists, and are used in large factories and warehouses for the same

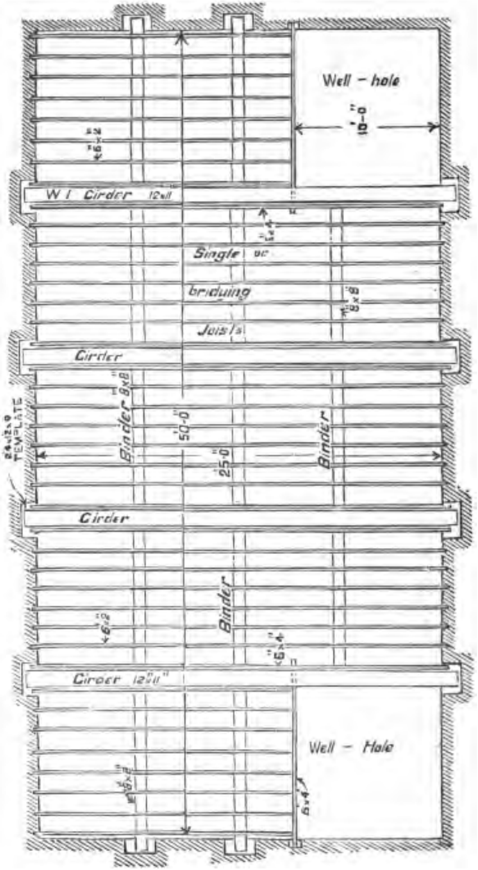


Fig. 252

reason as double floors where the span to be covered is great and to satisfy similar requirements, but to an enlarged extent that necessitates the use of double floors.

Scantling for girders of northern pine, distance apart from centre to centre, 10 feet, from Tredgold's Carpentry.

Clear span in feet.	Dimensions in inches.	Clear span in feet.	Dimensions in inches.
10	10 × 7½	16	13 × 8¾
12	11 × 8	18	14 × 8¾
14	12 × 7¾	20	15 × 9

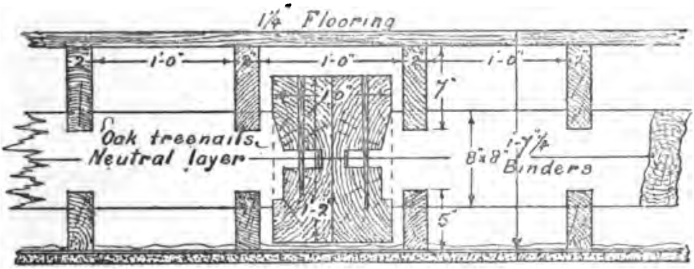


Fig. 253.

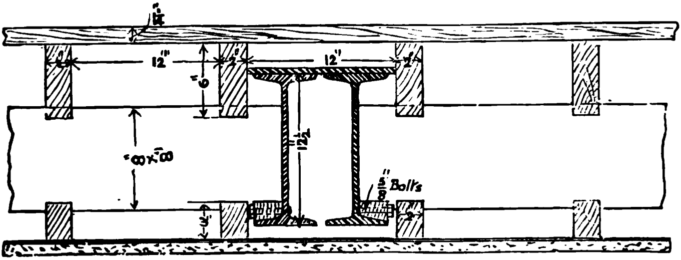


Fig. 254.

Figure 252 shows the plan of a double framed floor with girders and binders resting on stone templates.

Figures 253 and 254 give methods of applying wood or rolled iron or steel joists as girders.

Pockets in Walls.—The ends of all timbers penetrating walls should rest on stone templates, with a clear space of ½ inch at least, to allow of a free circulation of air around the ends of timbers, which, to prevent dry rot being induced, should in no case be allowed to touch the brickwork. Small cavities may be bridged at top with stone lintels, or the larger ones with rough relieving arch, as shown in figures 255 and 256.

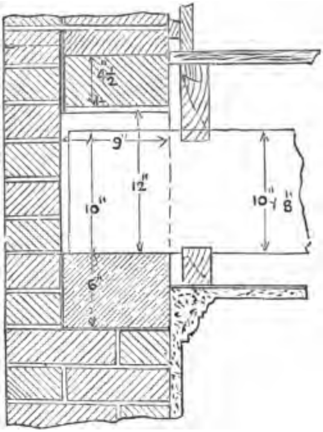


Fig. 255.

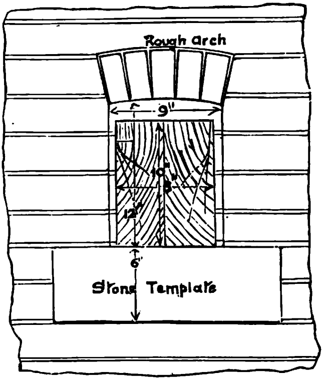


Fig. 256.

Ventilation of Floors.—All timbers of floors, especially those near the ground, should be well ventilated to prevent destruction by dry rot. The proper necessary ventilation may be obtained by the insertion of iron air bricks at intervals in the outer walls between ceiling and floor board levels, and by boring holes through the joist at the centre of their depth, so that the air may circulate through all.

The ventilation is more complete when, instead of a few iron air bricks, a course of perforated bricks is inserted at two or more sides of the floor.

CHAPTER VII.

PARTITIONS.

Partitions are screens used to divide flats into rooms, in addition to which they also often act as deep trusses to support floors.

Partitions may be built of brick, coke breeze, concrete. or wood, and also of various combinations of these materials.

Classification.—Timber partitions may be divided into three classes, viz:—

(*a*) Common.
(*b*) Supported at ends and carrying own weight only.
(*c*) Supported at ends and carrying floors.

Characteristics.—The advantages of timber partitions are first, lightness, an important consideration when the partition cannot have a solid bearing along its whole length, and can only be supported by a wall at either end. Secondly, rigidity, which is obtained by the triangulation of the framing, and rendering it possible to give the walls a substantial support, and to successfully resist external pressures. Thirdly, the ease with which they may be constructed in any position, and the facility with which loads may be transmitted and concentrated in any part or parts of the walls.

Timber partitions lack the fire-resisting properties of brick or concrete walls, and do not prevent the passage of sound to any great extent, and should not be erected in basements or floors next to the ground unless they are thoroughly protected from damp; brick or stone walls being preferable in this position.

Brick.—Brick is often used for partition walls which are built in the usual manner.

Coke Breeze.—Partitions are now largely built of coke breeze concrete; 4 parts of breeze to 1 of cement. Such material when used for partitions, is usually supplemented by light iron tie rods, placed horizontally when they are fixed into the walls, and vertically these being secured to light bar iron heads and sills. The concrete is poured into frames erected to receive it, in layers of about 1′ 6″ in height, until the whole is finished.

These partitions are light, fire-resisting and strong, the usual thickness of same being about 4½ inches.

Common Partitions.—Partitions designed to divide flats into rooms, where the floor is strong enough to support it, and consequently no need to truss the same, are called common partitions. They consist of a sill and a head with a number of uprights called studs tenoned to them, the whole fitting tightly between the floors below and above.

Care should be taken when placing the sill in position that it lies either at right angles to the floor joists below, or directly over one of the joists, if it be parallel to them, so that a solid and uniform support may be obtained along its entire length. Care must be taken that common partitions are not placed on the floor boards, between the joists, as in the event of the floor being taken up to be relaid, the partition would fail.

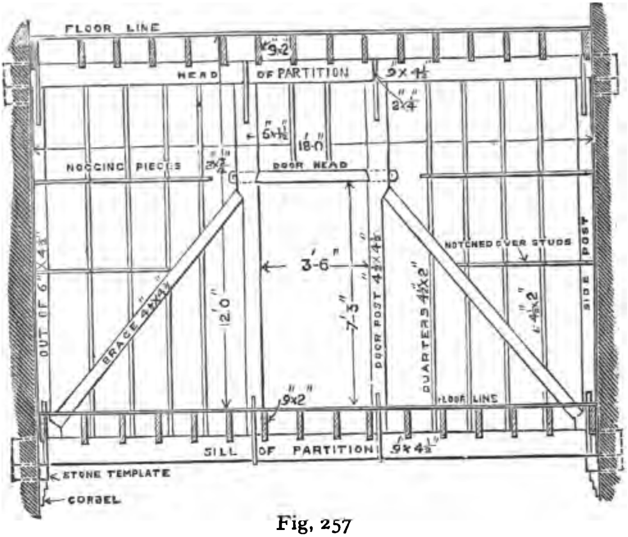
The studs, which consist of 4 × 2 quarters, placed 1′ 0″ to 1′ 3″ from centre to centre, are stump tenoned into the head and sill, and are stiffened in the direction of their length, by nogging pieces out of 4×2, cut tightly between the studs and nailed, or else out of strips 2″ × ¾″ let into the face of the studs and nailed, thus binding the whole together. The door studs, head and sill are formed of 4″ × 4″.

Bricknogged Partitions.—These are used for the prevention of fire and the passage of sound, and are a form of common partition; the spaces between the studs being filled in with brickwork 4½″ thick, the studs are made from 4 × 3 quarters, and are placed a distance of some multiple of a brick apart, usually either 2′ 3″ or 3′ 0″, and about every 2′ 0″ in height, a bonding strip out of 4″ × ⅜″ should be placed horizontally between the studs and nailed to them. Bricknogged partitions must always have a thoroughly solid support along their entire length, otherwise they are liable to settle and crack the plaster and cornice.

If the partition be of small dimensions they might with advantage be made entirely of brick, but where the partition exceeds 10′ 0″ in height, or has to help to support a floor, wood studs and bonding strips should be introduced to avoid any injury from vibration or shocks.

Coke breeze concrete is often used as a filling instead of brickwork, the studs having a number of nails driven in their sides, so that they project about 1½ inches to form a key for the concrete.

Partitions supporting their own weight.—These are employed when the floors are not strong enough to support the extra weight of a partition, and are therefore trussed so as to concentrate the weight of the partition on the



Fig, 257

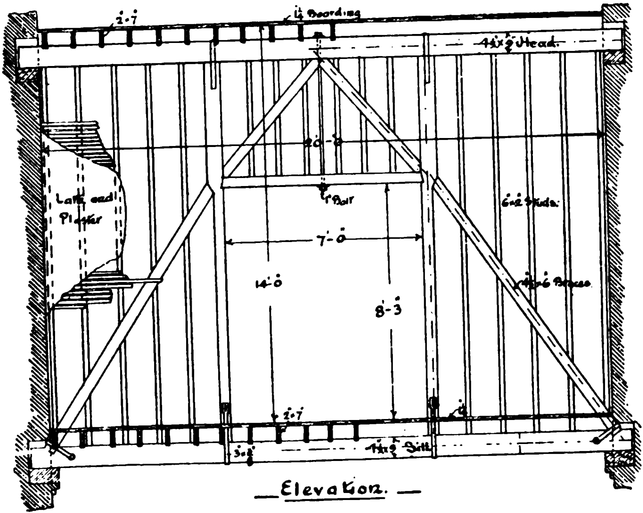


Fig. 258

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two supporting walls, as shown in figures 257, 258 and 259. It is better that the partitions should take their bearing on walls or supports at either end, and not rest on any intermediate support, such as a cross wall, at any point in its span, as the unequal settlement of the supports causes unsightly fractures in the plaster over the whole face of the partition.

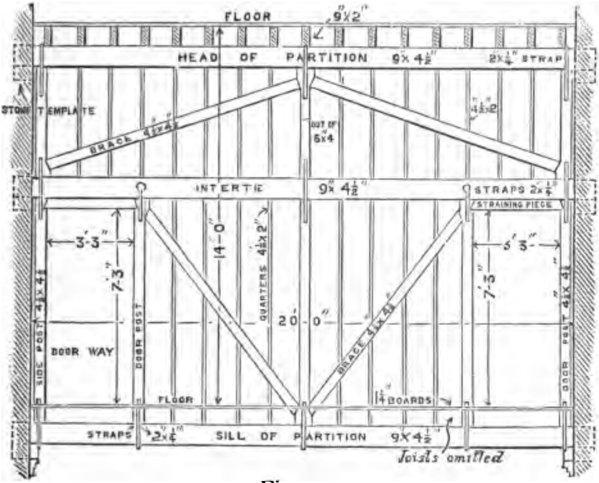


Fig. 259.

Trussing.—The object of trussing is to obtain a rigid unalterable frame, designed so as to throw all the weight carrying members into direct tension or compression, and to fail only when the members are stressed to their ultimate resistance. This is attained by triangulating the rectangular bays formed by the horizontal and vertical members by the addition of braces.

Distortion is prevented by arranging the loads to come over the apices of the triangles, when the stresses will be taken from all parts of the truss and transmitted to the supports.

All materials are inefficient to satisfy the theoretical requirements, owing to the expansion and contraction due to the variations in temperature. Timber is found to alter less in length than any other known material, and is therefore well adapted for trussed frames, provided means are taken to prevent the shrinkage in width affecting its length.

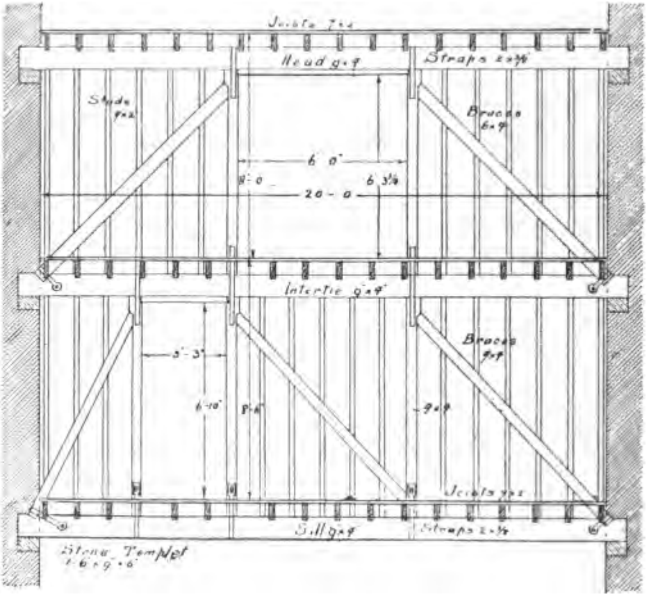


Fig. 260.

Care should be taken in designing the partition that the sill is supported at equal distances along its length as far as the door openings will allow; this is done by upright posts, tenoned into and connected to it by iron straps or bolts; the posts are supported at their upper ends by inclined braces, framed into them at that part the feet of the braces being bridled into the sill at a short distance from the ends, the weight of the partition thrown on the sill is thus taken up the posts and down the braces and are transmitted directly on to the walls.

The tensional members in timber structures are always a source of weakness, owing to the difficulty of making the joints sufficiently strong, and such works are always supplemented by iron straps or bolts. Timber is often superseded by long iron bolts with heads and screwed nuts for the members in tension.

Partitions supporting Floors.—Figures 257 to 260 shows partitions supporting floors, the principal difference between these and the preceding being that all the members have to be made proportionately stronger to carry the increased weight.

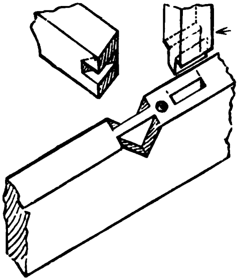
If the rooms be at all high another horizontal member is introduced, called an intertie, the duty of which is to distribute the pressure on the walls, and also to avoid the necessity of long braces.

The intertie is usually placed directly over the door heads, thus dividing the partition into two horizontal bays, which are trussed as before described.

In new buildings the plastering should be left until the walls have had time to settle, especially if they be of unequal heights and so allow the partition to adjust itself, otherwise the plaster will be cracked.

Studs.—The studs are stump tenoned into the sill head and intertie, as shown in figures 261 and 262, but where it intersects a brace it is simply cut to the bevil and nailed on, not tenoned into it, which would weaken the brace. The special duty of the studs is to form a fixing for the lathing, to interfere with the key of the plaster as little as possible; their thickness therefore should not exceed two inches. To resist the vibration and shocks caused by the slamming of the doors, the door studs should be stouter and generally 4″ by 4″; the angles are sometimes taken off these members to reduce the width on face with the object of preserving the plaster key, but a better method on all wide members is to counterlath, which consists in nailing laths at right angles to the covering lathing to all the main members of the partition of greater width than two inches.

Sills.—The sills in common partitions usually consist of 4″ by 4″ quarters, its special use being to receive the ends of the studs and to distribute the pressure evenly over the supports.



Fig, 261.

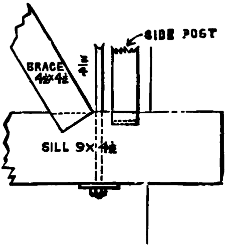


Fig. 262.

The sills in self-supporting partitions and those supporting floors vary in their depth, according to the weight to be carried. The sills receive the weight of the ordinary studs, which causes the former to be under a cross stress and are supported at their two ends by walls and at intervals by being hung to the uprights by iron straps or bolts; they also receive at both extremities the thrust of the braces, causing them to be under a tensional stress.

Intertie.—The intertie acts in a manner similar to the sill, its chief duty being to receive the inclined thrust of the braces and divert the pressure into a vertical direction, and also to distribute the weight of the partition over the wall.

Heads.—The head serves as a fixing for the studs; as a support for the joists above, as shown in figures 257 to 260, and as a straining beam to resist the thrust of the braces at their upper ends. It should always be connected at its extremities to the lower horizontal members by bolts or tensional bars.

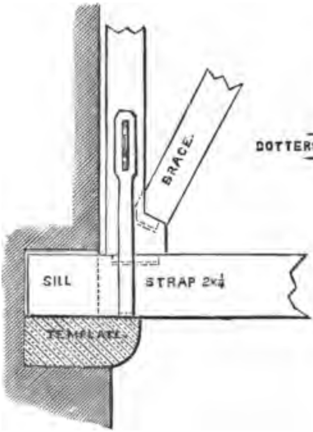


Fig 263.

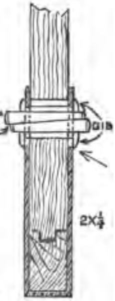


Fig. 264.

Braces.—The duty of the braces or inclined members is to give rigidity and to transmit the weight on to the walls, care should be taken that these are always arranged to be in compression.

When wooden upright members are employed the ends of the braces are usually framed into the upright, with the exception of the lower ends when they occur at the extremities of the sill or intertie, at which part they should be framed into those members by a bridle or an abutment joint, as shown in figures 263 to 267, but where iron bolts are used as tensional members, the joint at both head and sill should be a bridle, except where the extremities of two struts meet, when they should be mitred and butted against each other, and the horizontal member, and the stump tenoned into the latter.

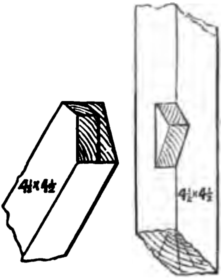


Fig. 265.

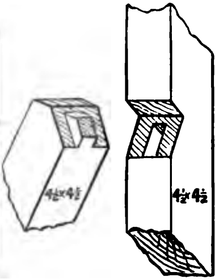


Fig. 266.

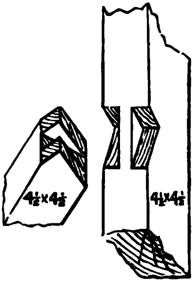


Fig. 267.

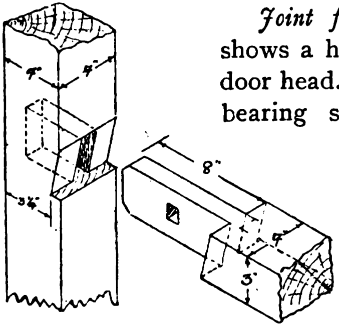


Fig. 268.

Joint for Door Head.—Figure 268 shows a housed and tenoned joint for door head. The housing is to obtain bearing strength, and the tenon is keyed to draw shoulders up tightly.

Fixing of Partitions.—The sill head and intertie should take their bearing on stone templates. If the partitions are arranged to act as cross walls they should be fixed, but if only to support themselves the ends of the timbers should rest in pockets so as to be thoroughly ventilated at all points.

The following are the scantlings of the timbers generally used :—

For common partitions, heads and sills = 4″ × 3″
Door posts and head .. .. .. = 4″ × 4″ and 4″ × 3″
Studs .. .. = 4″ × 2″

Double and Framed Partitions.—The scantlings of the principal members vary with the span, but are usually about the following:—

Heads	9″ × 4″
Sills	9″ × 4″
Intertie	7″ × 4″
Braces	4″ × 4″ to 7″ × 4″
Door Posts	4″ × 4″
Uprights	4″ × 4″
Studs	4″ × 2″

Weight of Partitions and Floors.—The weight of a square of partitioning may be taken at 1,480 to 2,000 lbs. per square of 100 feet.

The weight of a square of single joisted flooring without counter flooring, 1,260 to 2,000 lbs. per square.

The weight of a square of framed flooring with counter flooring, 2,000 to 4,000 lbs. per square.

Fixing for Plaster.—Wire netting fixed to the timber work is a good method of forming the fixing for the plaster instead of wood laths.

Regulations.—The model bye-laws require that the open space inside any partition wall of a new building or between the posts in any wall of such building to be stopped with brickwork, concrete pugging or other uncombustible material at every floor and ceiling. With this exception the model bye-laws do not control the construction of partition or division walls which simply separates one room from another in the same house.

CHAPTER VIII.

WOOD ROOFS.

Roofs—Are the coverings or upper parts of buildings constructed to keep rain and wind out, to preserve the interior from exposure to the weather, and should incidentally tie the walls, and give strength and firmness to the structure. They are built varying from almost horizontal surfaces to very steep pitches, the inclination being sometimes regulated by the climate, and should be designed to discharge any rain or snow that is likely to fall upon them. In countries favoured with mild weather, flat roofs would answer the purpose, whilst the colder climates and exposed positions would necessitate the use of steeply pitched roofs. The latter require a greater amount of material than the flatter ones, and consequently are more expensive. Amongst the numerous forms of wooden roofs, the following are very general:—

Flat, lean-to or shed, couple, couple close, collar beam, king-post and queen-post roof.

Flat Roofs.—Are similar to floors, but having a waterproof top, the upper surface being constructed to drain water off, and may be made as a lead flat, or as an asphalted concrete roof, or in other ways, but as water or snow is not thrown off, any defect will be severely tested.

Pitches of Roofs.—The following materials may be used for roofs, having the minimum inclinations, as given by Hurst:—

Covering.	Angle with Horizon.	Ratio of Rise to Span.
Tin	5° 43′′	$\frac{1}{20}$
Lead	„ „	„
Zinc	„ „	„
Copper	7 36	$\frac{1}{15}$
Corrugated Iron	11 18	$\frac{1}{10}$
Asphalted Felt	18 26	$\frac{1}{6}$
Slates, Large	22 0	$\frac{1}{5}$
„ Ordinary	26 33	$\frac{1}{4}$
Thin Slabs of Stone ..	„ „	„
Pantiles	33 40	$\frac{1}{3}$
Plain Tiles	45 0	$\frac{1}{2}$
Thatch	„ „	„

In localities exposed to much wind and rain the pitch of slates should not be less than $\frac{1}{3}$ of the span. The angle of 45° is the best for slates and pantiles, and admits of the use of interior of the roof for the construction of garrets.

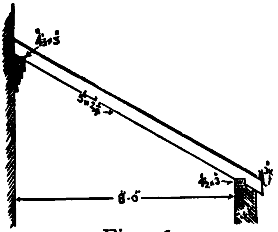


Fig. 269.

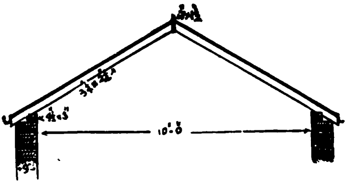


Fig. 270.

Lean-to or Shed Roof.—Are roofs formed with one slope only, used for outhouses against main buildings, as in figure 269, and for sheds.

Couple Roofs.—Are roofs composed of rafters with their feet fixed to wall plates, and in modern work meeting with

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their heads butting against a ridge piece, and without any tie except that afforded by the wall plate, no ceiling joists being used, as in figure 270. Such construction should not be used in permanent structures of greater span than 12 feet, as the rafters have the tendency to thrust out the walls.

The scantlings given for couple close roofs are applicable for this method.

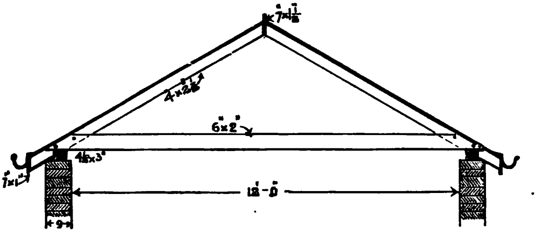

Fig. 271.

Couple Close Roofs.—For roofs about 12 feet in span, ties are used to prevent the walls from being thrust out by the rafters. The ties are usually formed by fixing the ends of the ceiling joists to the feet of rafters, as in figure 271.

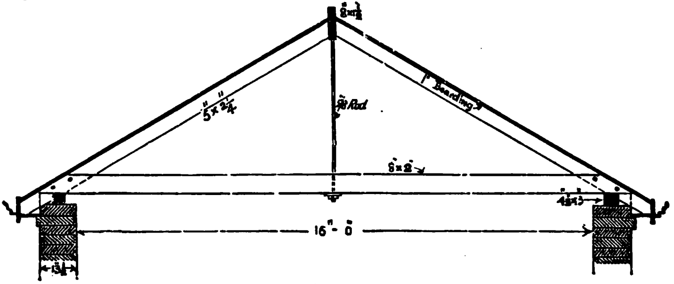

Fig. 272.

To prevent the bagging when carrying a ceiling, which would have the tendency to draw walls inwards, a king bolt is inserted, as in figure 272. The space in the roof is not altogether a waste, as it acts as a screen and a non-conductor of heat to the rooms immediately under same.

From 14 feet to 18 feet span it is wise to place a collar half way up the rafters to stiffen them, as in figure 274.

Scantlings for couple close roofs, of northern pine, rise ¼ span slated with Countess slates on boarding—as given by Wray.

Span from centre to centre of Wall Plate.	Rafters.	Ridge Board.	Ceiling Joists.	REMARKS.
8 feet	2¾ × 2	7 × 1½	4 × 2	
10 „	3¼ × 2¼	7 × 1½	5 × 2	
12 „	4 × 2½	7 × 1½	6 × 2	
14 „	4½ × 2¼	7 × 1½	7 × 2	These spans should have a collar, but in that case the dimensions given for collar beam roofs may be used.
16 „	5 × 2¼	8 × 1½	8 × 2	
18 „	5½ × 2¼	8 × 1½	9 × 2	

Collar Beam Roofs.—Roofs of this description are constructed by fixing beams half way up to the rafters, to support the same, and carry ceilings which are attached to the underside, and the lower part of rafters, as shown in figure 273. If the wall plates are securely fixed in the walls, and the latter are of an ordinary thickness, this method answers without ties, and has the advantage of adding extra height to the room below; but directly the wall plates give, the collars become stretched owing to the feet of rafters spreading, and the result is that the walls have the tendency to fall outwards, and besides which the non-conductivity of heat is reduced, as compared with the preceding method.

The collars are sometimes suspended from the ridge board to prevent them sagging by carrying ceilings.

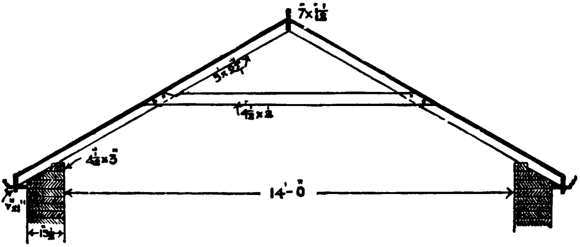

Fig. 273.

Scantlings for collar beam roofs, of northern pine, collar half way up without a tie, rise ¼ span slated with Countess slates on boarding—as given by Wray.

Span from centre to centre of Wall Plate.	Rafter.	Ridge.	Collar.	REMARKS.
8 feet	3 × 2	7 × 1½	2 × 2	In these spans it is not necessary to use the collar, except to carry the ceiling.
10 ,,	3½ × 2	7 × 1½	2½ × 2	
12 ,,	4 × 2	7 × 1½	3½ × 2	
14 ,,	3 × 2½	7 × 1½	4½ × 2	If there is no ceiling the collars may be reduced in depth, but they should be made thicker to prevent side buckling, as they will no longer be stiffened by the lathing.
16 ,,	3½ × 2½	7 × 1½	5 × 2	
18 ,,	4 × 2½	7 × 1½	5½ × 2	

Construction of Trusses.—The theory of trusses has already been stated in the chapter on partitions.

Above 18 feet span the roofs already described will not answer unless the timbers are abnormally large, the expense and unsightliness of which prohibits their use. Above that length of span framed roofs should he used, with trusses usually not more than 6 feet to 10 feet apart. When it is desirable to have the trusses a greater distance than 10 feet apart, trussed purlins would be used to support the roof coverings, and distribute the weight on the trusses.

The trusses are timbers framed together, consisting of principal rafters, tie beam posts, and struts. These frames carry purlins and sometimes pole plates, which in their turn support the common rafters, and should be so constructed that every member is in direct tension or compression with the exception of the tie beams carrying ceilings, the reason being that timber can resist very much greater loads when in direct tension or compression than when subject to transverse stress. This advantage is gained by designing triangulated frames, and arranging that the loads are supported at the angular points of the triangles. In setting out these frames it is wise to draw first the centre line of all the principal members, and to arrange the intersection of the centre lines of principal rafter and tie beam immediately over the centre of bearing.

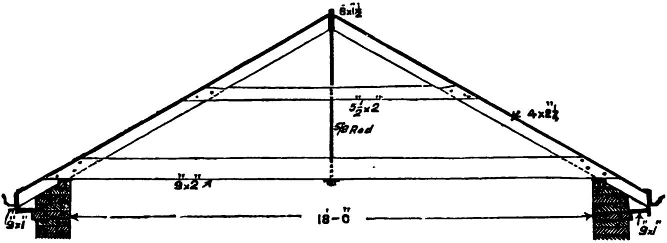

Fig. 274.

The truss should be so arranged that the distances between the supporting points of the principals, or the unsupported lengths of common rafters, are not more than 8 feet. The king-post form would thus be applicable for a roof with a principal rafter 16 feet long, or for a span of 28 feet. The best position for purlins is directly over the joints of principal rafters and their struts, and for the feet of principal rafters directly over their supports, and the struts should be inclined to the horizontal as much as possible, and their feet on king-posts, kept as low down as is practicable, as shown in figure 275; and the ends of tie-beams should not be built into walls, so as to come in direct contact with the brickwork, which is more or less damp, according to the hygrometric state of the atmosphere; but should be so arranged where the tie beam supports the ceiling, that the timbers of roofs are just sufficiently ventilated to prevent the dry rot without destroying the valuable non-conductive properties of the comparatively still dry air chamber.

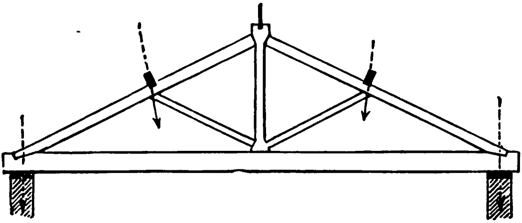

Fig. 275.

Figure 276 gives an illustration of a king-post roof-truss for 25 feet span, showing methods of arranging timbers to form taper shaped parapet and eaves gutters. In London and adjoining districts all external walls, if adjoining gutter, to have parapet walls, at least one brick thick, 12 inches high, the height being measured from highest point of gutter, and party walls to have parapets 15 inches high above roof. The sole piece of taper shaped gutters should never be less than 9 inches at lowest point, so as to be wide enough for a man to stand upon it.

Feet of Principal Rafters.—These should rest immediately over the walls, as in figures 277 and 278, the best position being the centre line of rafter meeting the centre line of tie beam perpendicularly over centre of support, as in figure 275, and not as shown in figure 461; the latter method is often adopted because less material is used for covering the same span, but is subject to the defect of causing the tie-beam to be in transverse strain from the load above

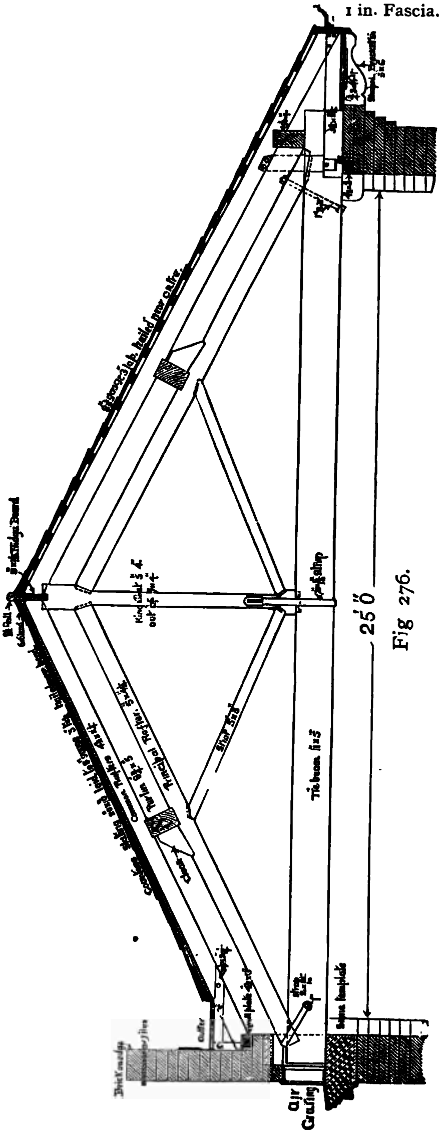

Fig 276.

as well as from the ceiling below. The bridle joint, with heel strap, may be used, as in figure 277, whenever the end of the tie-beam is in danger of being sheared, in other cases by one of the joints, shown on pages 80 and 81, taking the precaution of having the feet of rafters well strapped or bolted, especially so, if there is any danger of the latter slipping away from their abutments.

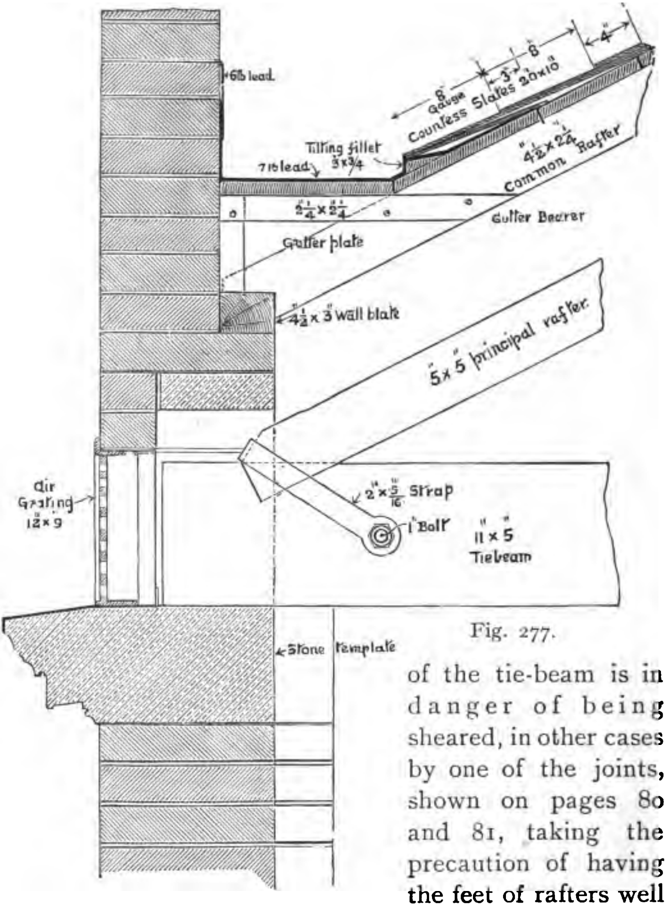

Fig. 277.

Tie-beams.—It is advisable to let the ends of tie-beams rest on stone templates, over thickness of walls, or even project somewhat over where possible, as in eaves roofs, so that the load may be taken directly by walls; but, whichever method is adopted, care should be taken to ensure a sufficient circulation of air, to prevent timbers being attacked by the dry-rot; this may be accomplished by inserting in walls, opposite ends of beams, large air-bricks, as shown in figure 277, or, when eaves gutters are used, by inserting iron gratings in the soffits of eaves, as shown in figure 278, or, in roofs for stations, workshops, etc., where plenty of ventilation is no objection, by having open soffits to the eaves, and by various other methods which may suggest themselves.

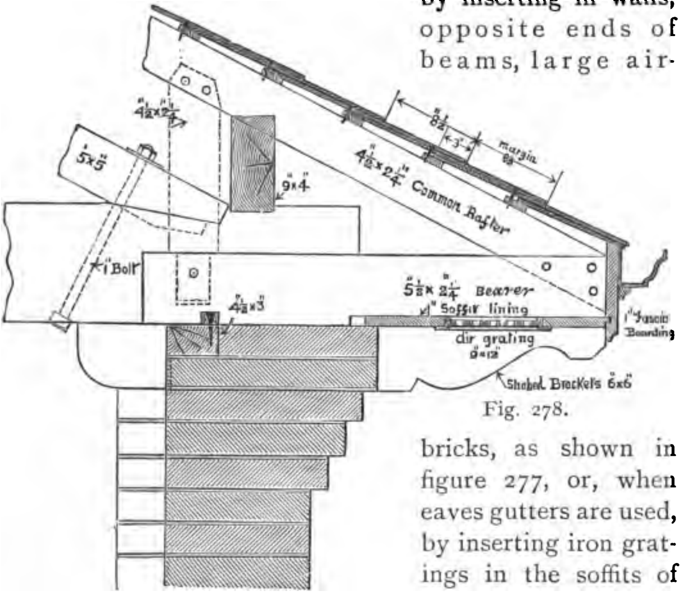

Fig. 278.

Pole Plates are timbers supported only by the trusses, carrying the feet of common rafters, and are necessary when parallel gutters are to be formed, as in figure 462, or when all the load must be carried by the piers or portions of walls supporting tie-beams, to avoid any openings that may occur in the wall, and be supported directly by the tie-beam over the centre of wall, as in figure 278.

Wall Plates.—Instead of using pole plates when taper shaped or eaves gutters are to be constructed, where advisable the brickwork may be built up to carry wall plates, as in figure 277, which distributes a portion of the load of roof directly on the walls.

Gutter Bearers.—The gutter boards, usually 1 inch in thickness, may be supported by 2 inch by 2 inch, or

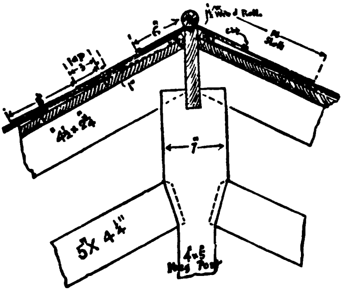

Fig. 279.

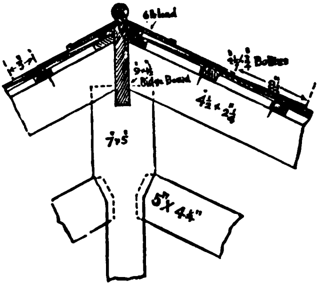

Fig. 280

3 inch by 2 inch gutter bearers, which are halved and nailed to every rafter, as shown in figure 277.

Eaves Gutters.—One method of forming eaves gutters is shown in figure 278, with an iron grating fixed to the bearers of soffit, to ventilate timbers of roof, and shows a pole plate directly over the wall. Dotted lines show an upright tenoned into horizontal bearers and common rafters, which may be inserted occasionally to prevent bearer tilting, or if used with every common rafter would dispense with the necessity of a pole plate.

Head of Principal Rafter.—Figure 279 shows a method of forming junction of principal rafter with king-post with single shoulder. Where the difference of width of head and lower part of king-post is small, the joint may be made by cutting the upper portion of shoulder square with principal rafter, and the remaining part butting against king-post, as shown in figure 280, which may be secured by three-way straps, as shown in figure 284.

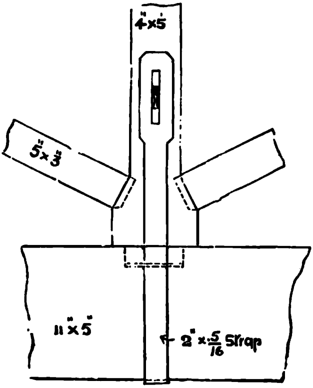

Fig. 281.

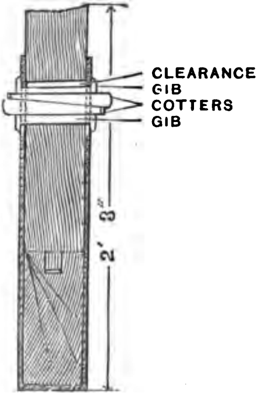

Fig. 282.

Ridge Boards are the highest timbers of roofs, and form the abutments for the heads of common rafters, which are usually spiked to them, but in good work are housed in. The ridge board may be held in position by slotting the head of king-post, as in figures 279 and 280.

Struts and King-post Joint.—May be made similar to head of principal rafter and king-post, under the same conditions; but the width of foot of king-post is usually sufficient to admit of the joint shown in figure 281, which, being simple and easy to make, should always be used.

King-post and Tie-beam Joint.—These are sometimes held together by bolts only, the tie-beam being brought to the required camber by ropes suspended from the ridge (one inch in twenty feet generally being considered sufficient to prevent any unsightly settlement), the shoulders of king-post having been cut to the required length, or with straps secured by bolts; but the best arrangement is that of gibs and cotters, which allow the joint to be drawn up at any time an open shoulder is observable, by leaving clearances, as shown in figure 282.

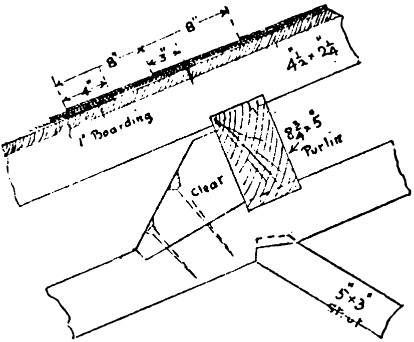

Fig. 283.

Purlins.—Are the horizontal members of the roof, supported by the trusses, and in their turn carry the common rafters between the pole or wall plates and the ridge pieces. They should not be more than eight feet from the next support of common rafters, and should be cogged to the principal rafters directly over the struts. In some forms of roofs, where common rafters are dispensed with, they carry the boarding to receive slating, as in figure 324.

Junction of Struts and Principal Rafters.—These may be arranged as in figure 283, and are sometimes held together by straps, and should be placed directly under the stress transmitted by the purlin above, as in figure 275; the latter distributing the load from roof above when acted on by the wind on that side.

Common Rafters.—Are the sloping timbers to which roof coverings are attached. In framed roofs they are sup-

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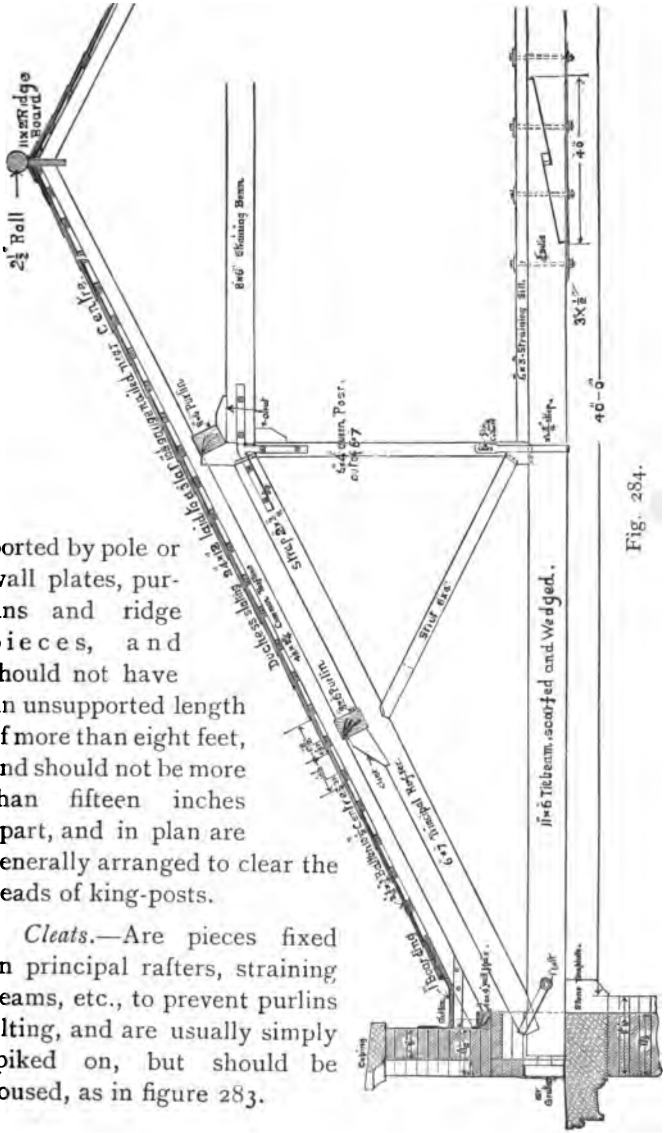


Fig. 284.

ported by pole or wall plates, purlins and ridge pieces, and should not have an unsupported length of more than eight feet, and should not be more than fifteen inches apart, and in plan are generally arranged to clear the heads of king-posts.

Cleats.—Are pieces fixed on principal rafters, straining beams, etc., to prevent purlins tilting, and are usually simply spiked on, but should be housed, as in figure 283.

Queen-post Roof Truss.—Figure 284 shows an elevation of same, suitable for spans from thirty to forty-five feet, the parts being easily understood from what has been already stated about the king-post truss. The tie-beam, if of northern pine, is usually in two lengths, and scarfed. A straining sill is sometimes fixed between queen-posts to prevent the stress from struts shearing the tenon of queen-posts.

Scantlings for wood roofs, of northern pine—trusses 10 feet apart, ¼ pitch, slate covering.—*Hurst's Handbook.*

Span in feet.	Tie-beam.	King-post.	Queen-post.	Principal Rafters.	Straining Beam.	Struts.	Purlins.	Common Rafters.
20	9½×4	4×3	—	4×4	—	3½×2	8×4	3½×2
22	9½×5	5×3	—	5×3½	—	3¾×2¼	8¼×5	3¾×2
24	10½×5	5×3½	—	5×4	—	4×2½	8½×5	4×2
26	11½×5	5×4	—	5×4¼	—	4¼×2½	8¾×5	4¼×2
28	11½×6	6×4	—	6×3½	—	4½×2¾	8¾×5¼	4½×2
30	12×6	6×4½	—	6×4	—	4¾×3	9×5½	4¾×2
32	10×4½	—	4½×4	4½×6¾	6¾×4½	3¾×2¼	8×4¾	3½×2
34	10×5	—	5×3½	5×6½	6¾×5	4×2½	8¼×5	3¾×2
36	10½×5	—	5×4	5×6¾	7×5	4¼×2½	8½×5	4×2
38	10×6	—	6×3¾	6×6	7¼×6	4½×2½	8½×5	4×2
40	11×6	—	6×4	6×6½	8×6	4½×2½	8½×5	4¼×2
42	11½×6	—	6×4½	6×6¾	8¼×6	4½×2¾	8¾×5¼	4½×2
44	12×6	—	6×5	6×7	8½×6	4½×3	9×5	4¾×2
46	12½×6	—	6×5½	6×7¼	9×6	4¾×3	9×5½	5×2

The members of king and queen-post roofs are under the following strains:

Compression.—Principal rafters, straining beams, struts.

Tension.—King-posts, queen-posts, tie-beams without ceilings attached.

Transverse or Cross.—Purlins, common rafters.

Transverse and Tension.—Tie-beam with ceiling attached.

CHAPTER IX.

COMPOSITE ROOFS.

Tensional Members.—The ties of trusses in composite roofs are often constructed of wrought iron, because the latter has great tensile strength as compared with timber; moreover, the rectangular section in beams is wasteful, as the mortises or housings made at the joints in cutting the fibres reduce the effective sections considerably, consequently large pieces of timber have to be used to do the required work: this adds great weight to be carried by the supports, and interrupts the passage of light in open roofs. Wrought iron ties would be oftener employed if it were not for the trouble and delay caused in getting small quantities executed and difficulty of fixing ceiling joists where such are required. Suspending the ceiling joists by iron straps to the ties is a somewhat unsatisfactory recourse sometimes adopted.

Objection. — Composite roofs of wood and iron are subject to this objection, that the timber principals do not expand or contract appreciably with the changes of temperature, while the iron members do so considerably. This can easily be imagined to have the effect of lengthening the tie until it ceases to act, or until the feet of the principal rafters spread; or, again, the contraction of the tie rod may have the effect of bending wood principals or overstraining the tie rod.

Tie-beams.—The trusses that have timber tie-beams are suitable for supporting ceilings.

Principal Rafters.—The principal rafters in composite roofs usually are of timber, this being convenient for fixing the purlins.

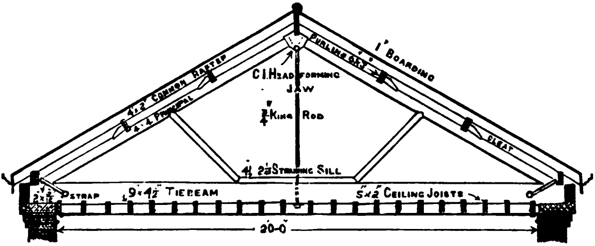


Fig. 285.

Typical Trusses.—The following are typical composite trusses:—For spans from 20 feet to 30 feet.

Figure 285 shows a wrought iron king bolt and cast iron head, the joint at foot of struts being made by introducing a straining piece. Figure 286 illustrates a truss for a 20 feet span, the tensional members being of wrought iron, while the struts and principal rafters are of timber.

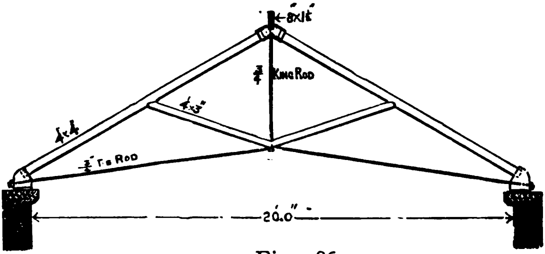


Fig. 286.

The German truss may be used, introducing a king bolt and tie rods, those being the members in tension, as illustrated in figure 287.

Figure 288 shows wrought iron tension and tie rods with cast iron struts, the principals only being of timber.

For spans from 30 feet to 40 feet, the king bolt and queen bolt forms of truss may be used, those members being of wrought iron and constructed as illustrated in figure 289. The tie-beam being of timber and well tied up by the king and queen bolts, render these trusses suitable for supporting a ceiling.

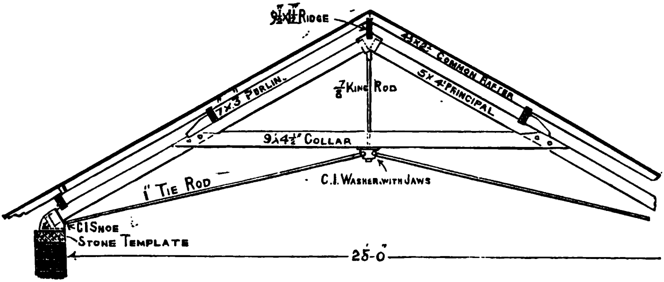


Fig. 287.

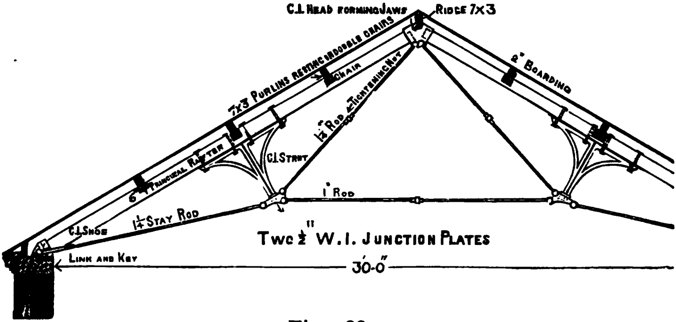


Fig. 288.

Feet of Principal Rafters.—Iron ties may be secured to wood principals by passing them through holes bored through principal and pole-plate, and held by nuts and bevelled washers, as in figure 290, or bolted to cast iron shoe, which receives foot of principal, as illustrated in figure 291.

Head of Principal Rafter.—Cast iron heads are made to form the abutment for the upper ends of principal rafters, with a hole cast for king bolt to pass through, as shown in figure 292, or a link joint is made in one tension rod, through which the other passes, and each is fixed to the back of principal rafters having an iron plate to distribute the pressure and prevent nuts crushing the wood as illustrated in figure 293.

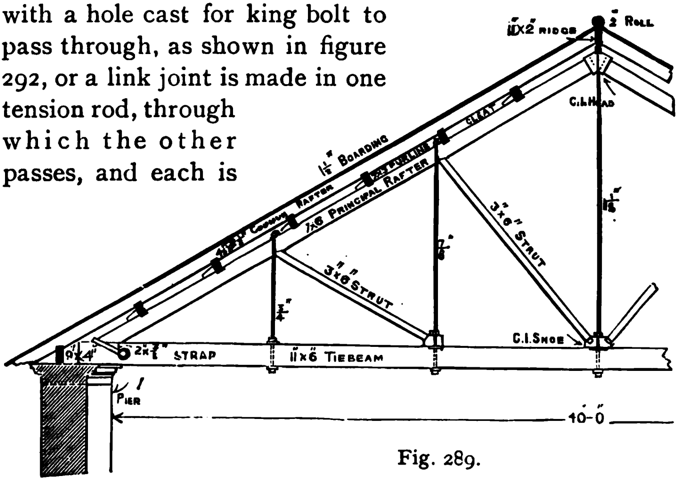


Fig. 289.

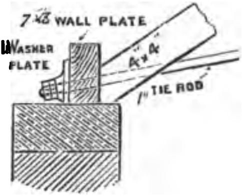


Fig. 290.

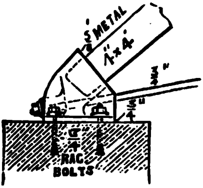


Fig. 291.

Timber Strut, Principal and Queen Bolt.—The usual joint between the strut and principal is a single abutment as in figure 294, with queen bolt passing through a hole bored through principal and fixed by a nut screwed on bevelled washer to back of principal.

Feet of Struts.—This joint may be made by using a cast iron shoe, as shown in figure 295, when timber struts and tie-beam are used.

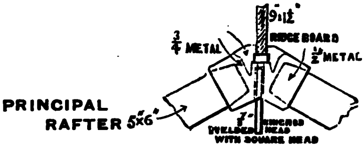


Fig. 292.

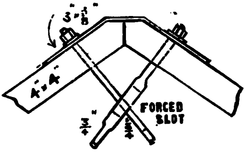


Fig. 293.

Feet of King or Queen Bolts.—These may pass through cast iron sockets, which are indented into the tie-beam and receive the wood struts. The tie-beam is secured by

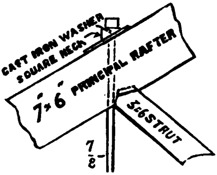


Fig. 294.

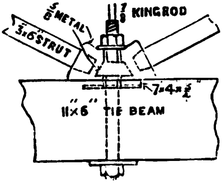


Fig. 295.

screwed nuts and washers on king bolt over head of socket and under tie-beam, as illustrated in figure 295.

Feet of Tension Rods.—These are secured to ties by means of two wrought iron plates, illustrated in figure 288, which receive between them the foot of cast iron strut, which may be fixed by a keyed or cottered joint, similar to the one shown in figure 330.

CHAPTER X.

IRON ROOFS.

Iron Roofs.—The great superiority of iron and mild steel over timber in stress resisting properties, the great varieties of economical and suitable sections in the market, the ease with which it can be packed and transported, and its resistance to fire and insects, is gradually displacing timber as a material for roofs of large or even moderate dimensions, and great attention has been given to the most economical methods of designing same.

Strains on Trusses.—Every member of a truss should be in either direct tension or compression ; but in smaller roofs the purlins are often distributed along the length of a principal rafter, causing it to be in transverse strain ; in that case the distance between struts should not be great, otherwise the principal rafter will have to be uneconomically large. Struts should be arranged as short as possible, and as many braces as possible in tension.

Cast Iron can be advantageously employed for shoes and short struts.

Wrought Iron and mild steel is sometimes employed for every part of the truss, as illustrated in fig. 302 to 309.

Mild Steel.—Is used for every part for which wrought iron may be used, but with reduced sections.

Rivetting and Bolting.—In making the connections with members, rivets may be employed up to 1 inch in diameter, but where a larger diameter is required bolts are used; the latter are more expensive, but have the advantage of allowing the roof to settle somewhat, and the joints to adjust themselves under the load.

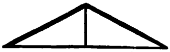


Fig. 296.
Span 15 ft. to 20 ft.

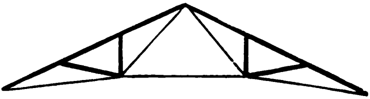


Fig. 299.
Span 30 ft. to 40 ft.

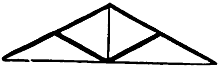


Fig. 297.
Span 20 ft. to 30 ft.

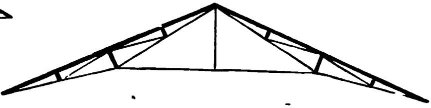


Fig. 300.
Span 40 ft. to 50 ft.

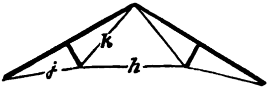


Fig. 298.
Span 20 ft. to 30 ft.

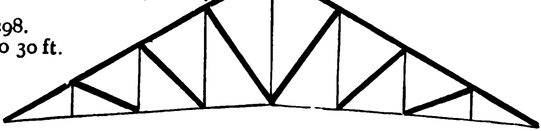


Fig. 301.
Span 40 ft. to 50 ft.

Typical Trusses.—Figures 296 to 301 show outlines of iron trusses for spans, varying from 15 to 50 feet. Thin lines indicate the members in tension, thick lines in compression.

The following table gives the dimensions of heads

Iron Roof Truss for 20 ft. Span.

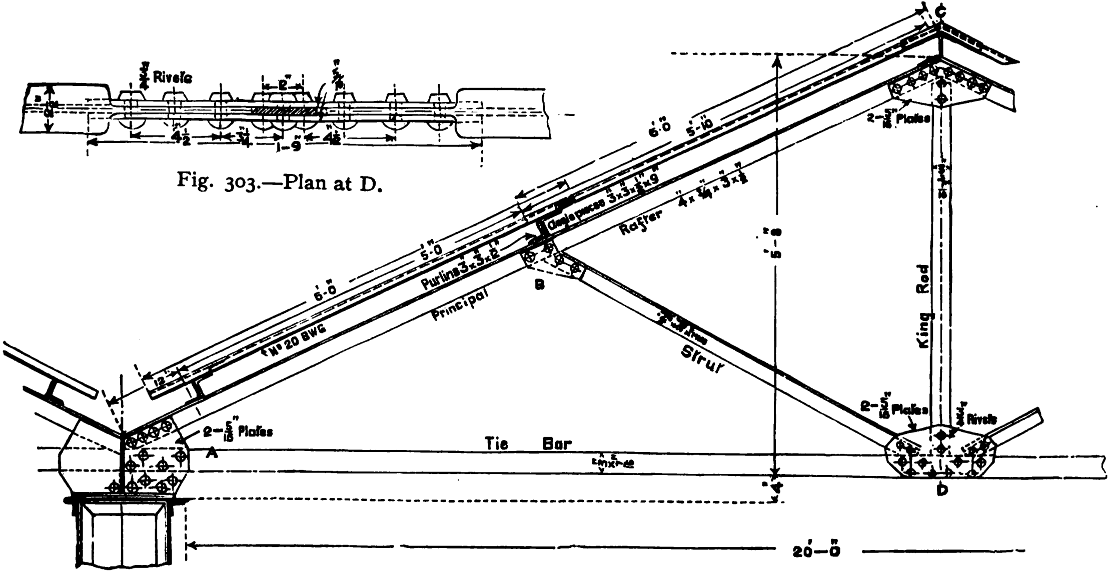


Fig. 303.—Plan at D.

Fig. 302.—Half Elevation.

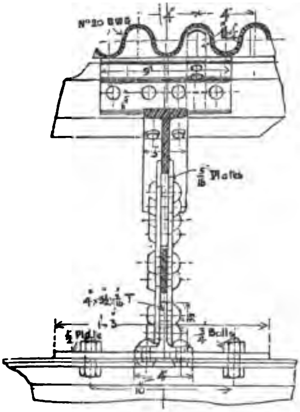


Fig. 308.—Elevation at A.

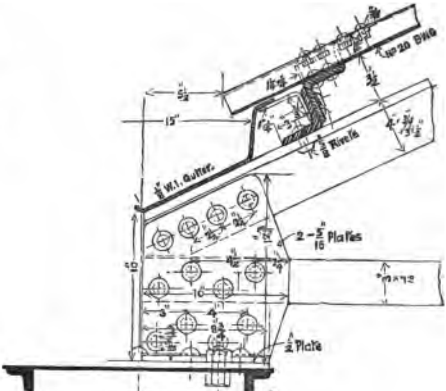


Fig. 306.—Detail at A.

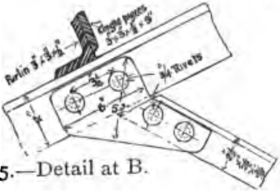


Fig. 305.—Detail at B.

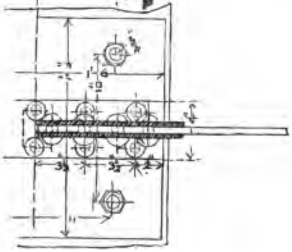


Fig. 307.

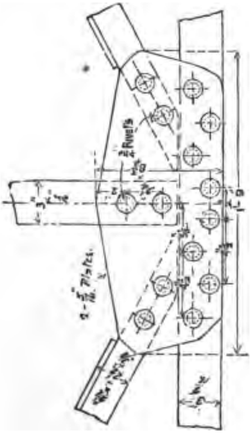


Fig. 304.—Detail at D.

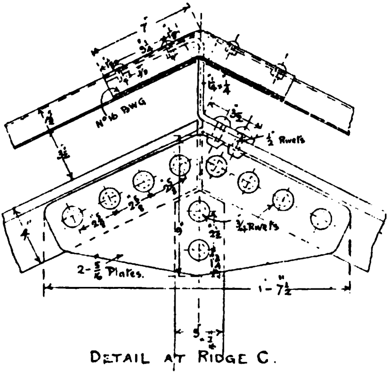


Fig. 309.—Detail at Ridge C.

IRON ROOF TRUSS FOR 25 FT SPAN.

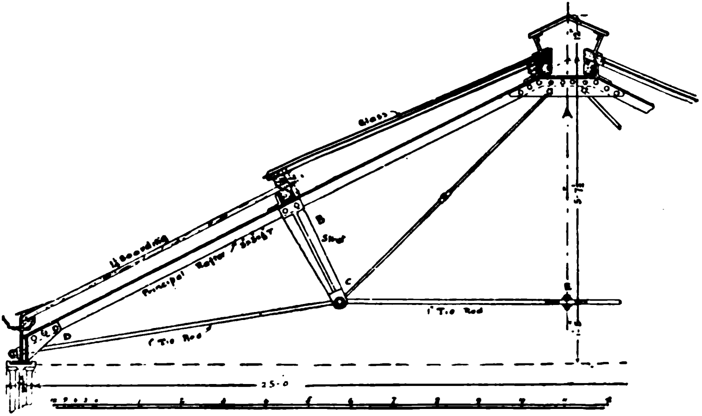


Fig. 310.

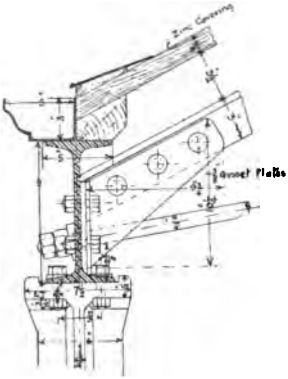


Fig 311.

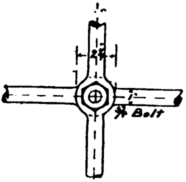


Fig. 316

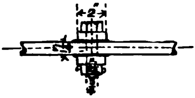
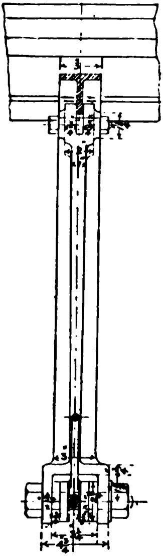


Fig. 317.



FRONT ELEVATION.

Fig. 313.

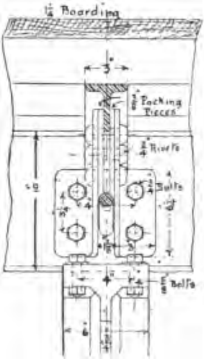


Fig. 312.

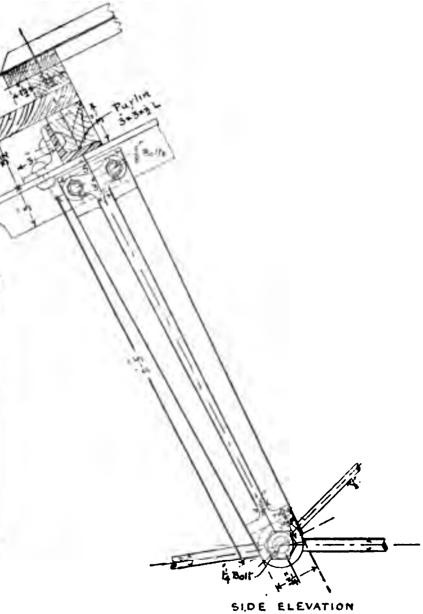


Fig. 314.—Detail at B.

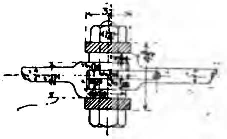


Fig. 318.
Detail at C.

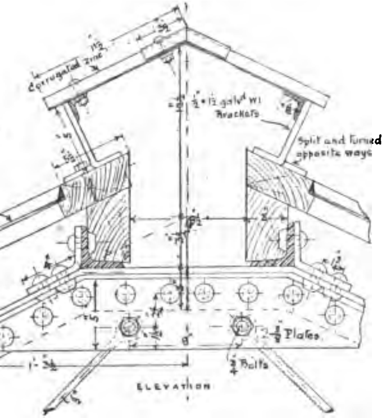


Fig. 315.—Detail at A.

Iron Roof Truss for 30 ft. Span.

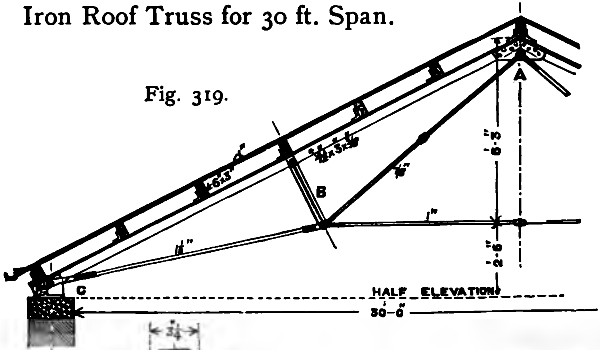


Fig. 319.

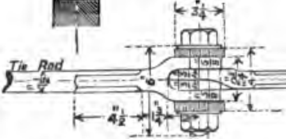


Fig. 322.

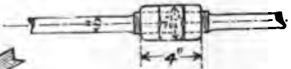


Fig. 323.

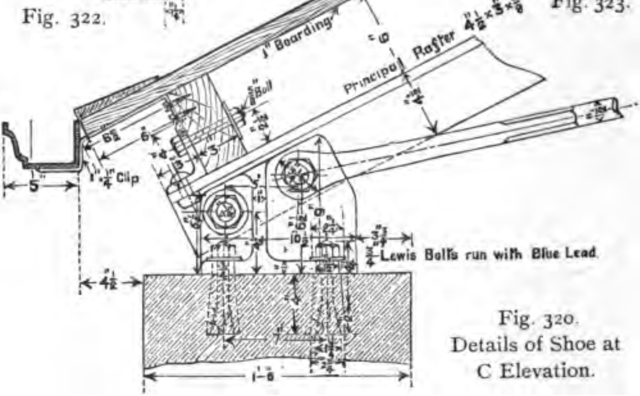


Fig. 320. Details of Shoe at C Elevation.

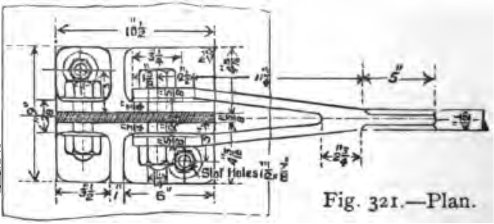


Fig. 321.—Plan.

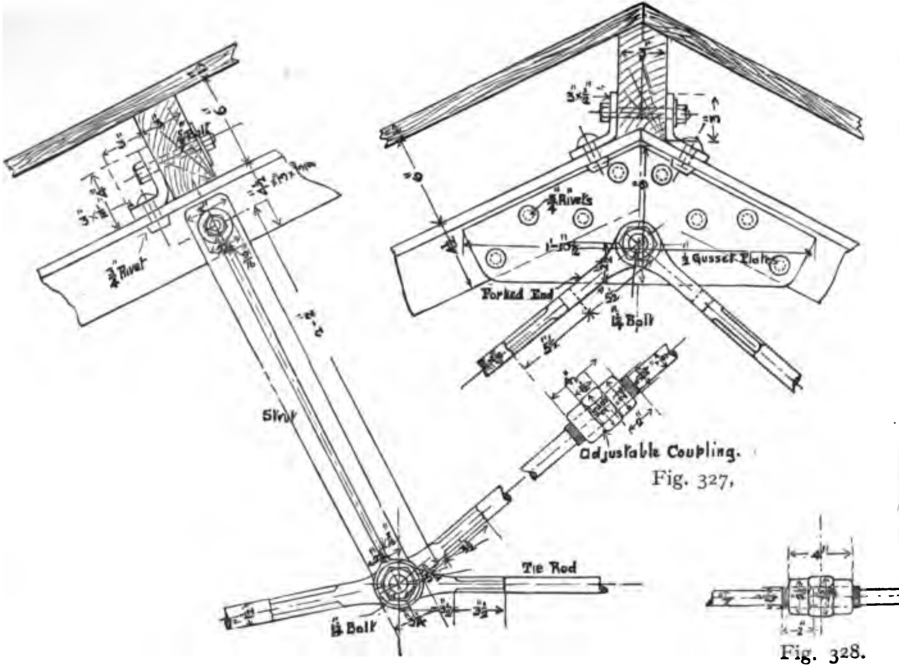


Fig. 324.—Detail of Strut and Purlin B.

Fig. 326.—Detail at Ridge A.

Adjustable Coupling.
Fig. 327.

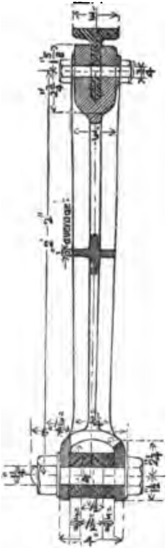


Fig. 325.—Side Elevation of Strut B.

Fig. 328.

and nuts of square and hexagon bolts in the ratio of the diameter of the bolt :—

	Diameter of Head and Nut between Faces.	Diameter of Head and Nut across Angles.	Thickness of Head.	Thickness of Nut.
Hexagon ..	1·5	1·75	·75 to 1	1
Square	1·5	2·12	·75 to 1	1

The following table gives the dimensions of the various rivet heads in the ratio of the diameter of the shank :—

	Diameter of Head.	Thickness of Head.
Cup	1·7	·6
Countersunk	1·6	·4
Pan head	1·6	·7
Conical	2	·75
Conoidal	2	·7

Hipped Roofs.—Trusses with perpendicular members are considered better for the trusses of hipped roofs.

Sections to resist Tension.—May be round or one or more flat bars, with their greatest dimensions vertical, which form has the advantage of sagging or deflecting less under its own weight.

Sections to resist Compression.—Angle iron, tee iron, and channel iron, are generally used. Double channel iron, kept apart by pipe distance pieces with small bolts passing through and rivetted at ends, forms a stiff section, but is more costly than tee iron. Angle irons kept in a similar manner render the connections easy to make. Flat bar iron kept apart by distance pieces so arranged as to bulge them out in the centre and kept together by rivetted bolts, form a good and simple joint. Short struts may be made of cast iron of cross section with forked ends, as in figures 324 and 325, for a bolt to pass through and form the connection.

Sections under Transverse Strain.—Rolled iron joist, as in figure 342, angle and tee irons, are used for purlins, as in figure 302.

Pitch of Iron Roofs.—The pitch usually adopted for small roofs is $\frac{1}{4}$th, and for large $\frac{1}{5}$th the span, but this is sometimes governed by the nature of the covering. Where an occasional leak is of little importance, the flatter pitch may be used.

Camber of Tie Rods.—Tie rods are usually cambered $\frac{1}{80}$ to $\frac{1}{40}$ the span and in some cases more. This is done to reduce the length of the struts and to gain greater height above the floor level.

Coverings of Iron Roofs.—Corrugated iron, as in figure 308, especially where the storing of the rainfall is a matter of great importance. Slates, zinc, and glass, as illustrated in figure 315, are usually the coverings employed for iron roofs.

Tightening up Joints of Trusses.—Tension or tie rods are drawn tightly up or slackened by means of gibs and cotters, as in figures 344 and 345, or by adjustable screw couplings or union joints, as in figure 327. In the latter case the tension rod is in two pieces, the adjoining ends of which are thickened and screwed with right and left-handed threads; the rotation of the coupling piece then draws the ends together or urges them farther apart.

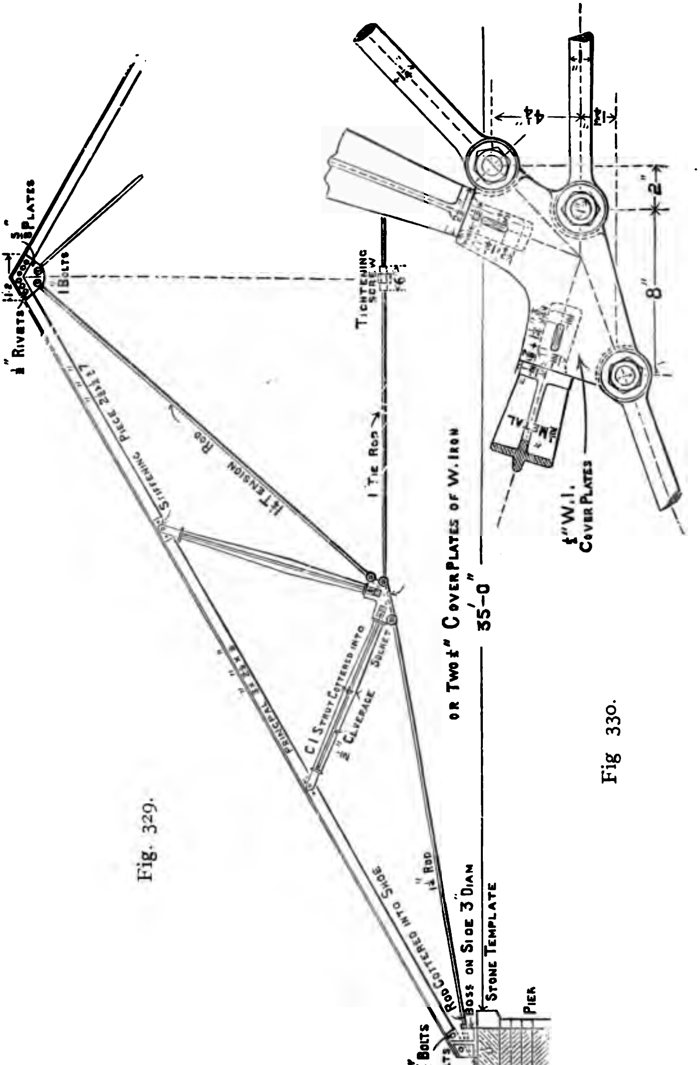


Fig. 329.

Fig 330.

Iron Roof Truss for 40 ft. Span.

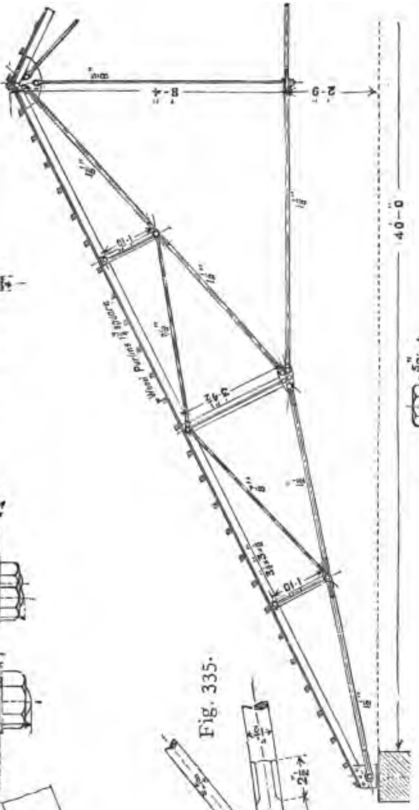


Fig. 331. Half Elevation.

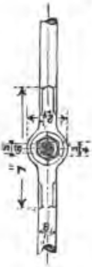


Fig. 339.

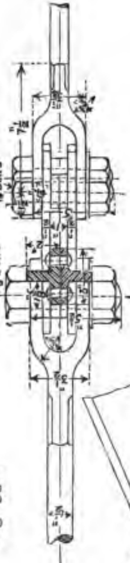


Fig. 338.

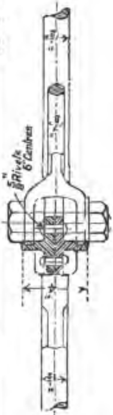


Fig. 341.

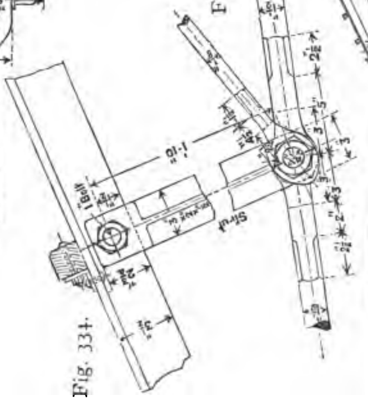


Fig. 335.

Fig. 334.

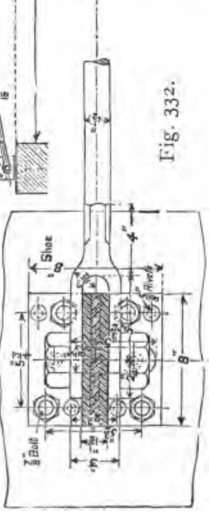


Fig. 332.

Details for 40 ft. Span.

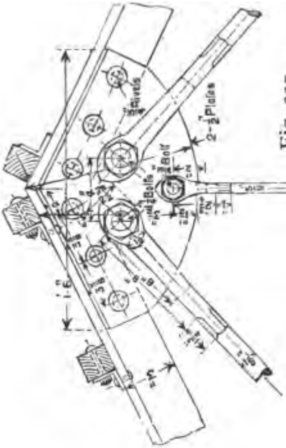


Fig. 337.

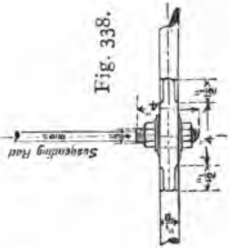


Fig. 338.

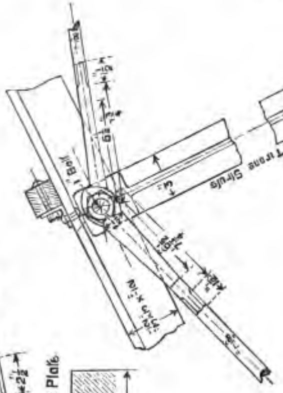
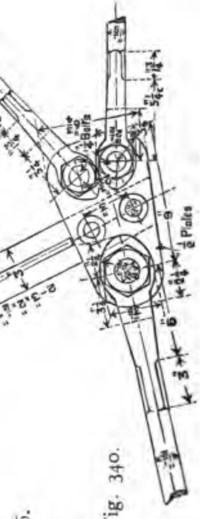


Fig. 336.



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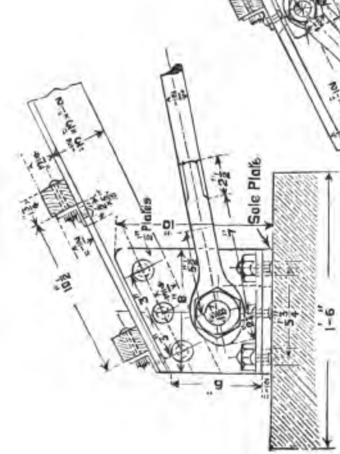
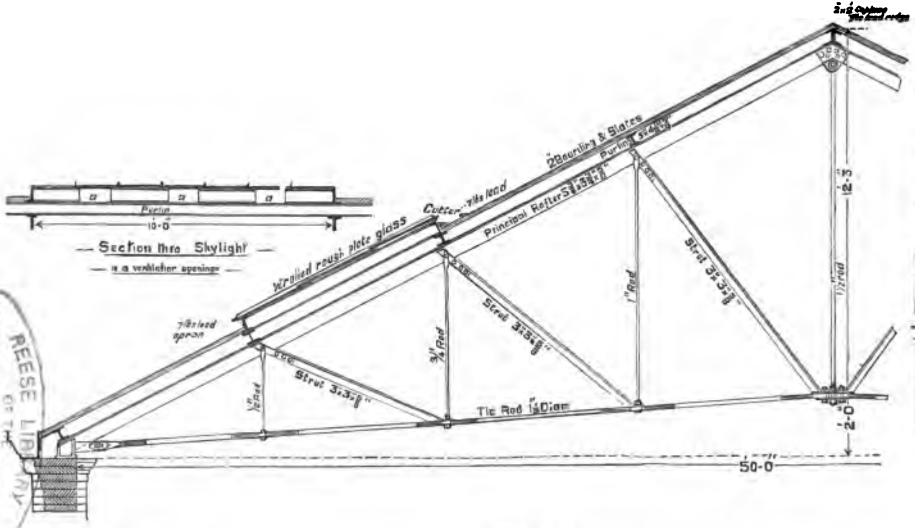


Fig. 333.

Iron Roof Truss for 50 ft. Span.



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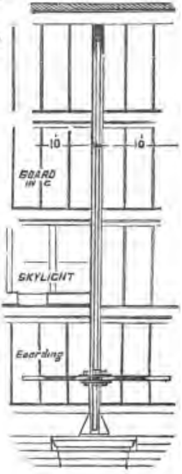

Fig. 343.

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Junction at Feet of Principal Rafters.—These may be constructed by rivetting cover plates over web of principal rafter and flat tie rod, as shown in figure 302, by forking tie rod over web of principal rafter and shoe, as in figures 320 and 321, or by arranging cover plates to fork over web of principal and bolting in both methods to cast iron shoe, having side cheeks cast on, to prevent the principal moving laterally, as in figure 344. The shoes are bolted on one side to stone template, and on the other by passing bolts through elliptical holes cast in shoe as in figures 344 and 345, to allow the truss, by being free, to

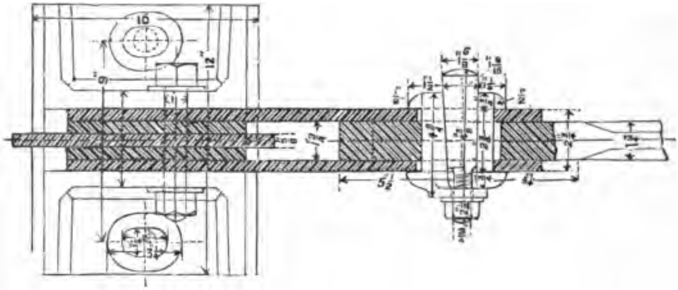
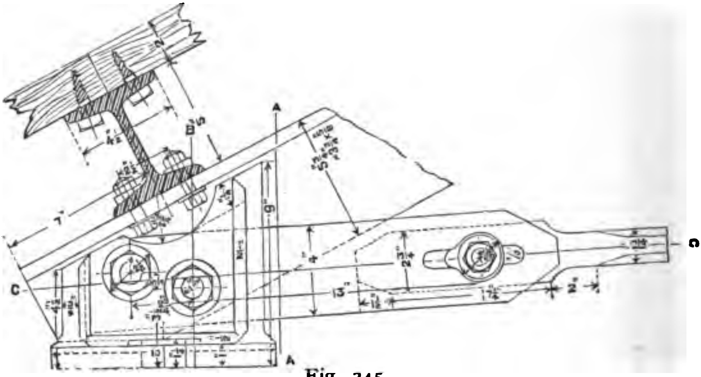


Fig. 344.



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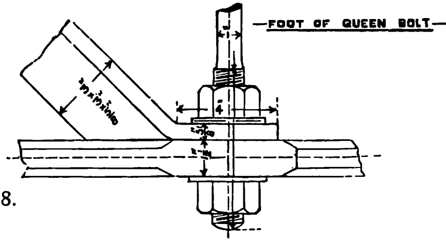
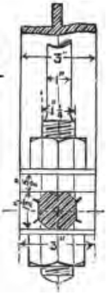


Fig. 358.



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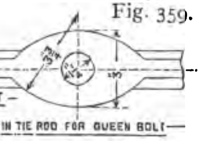


Fig. 357.

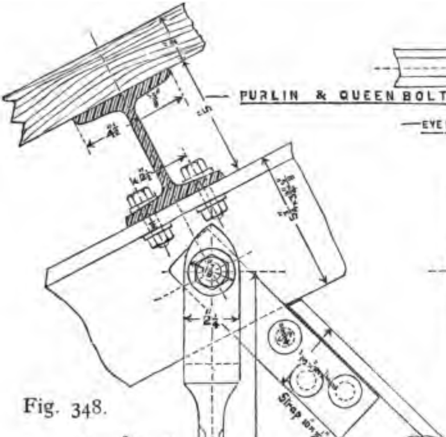


Fig. 348.

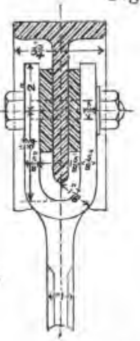


Fig. 349.

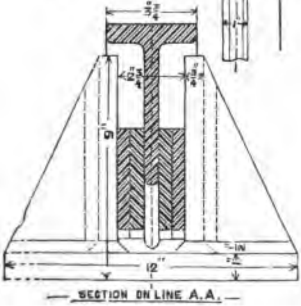


Fig. 346.

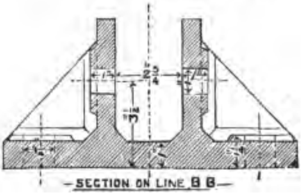


Fig. 347.

Fig. 353. Fig. 351. Fig. 352.

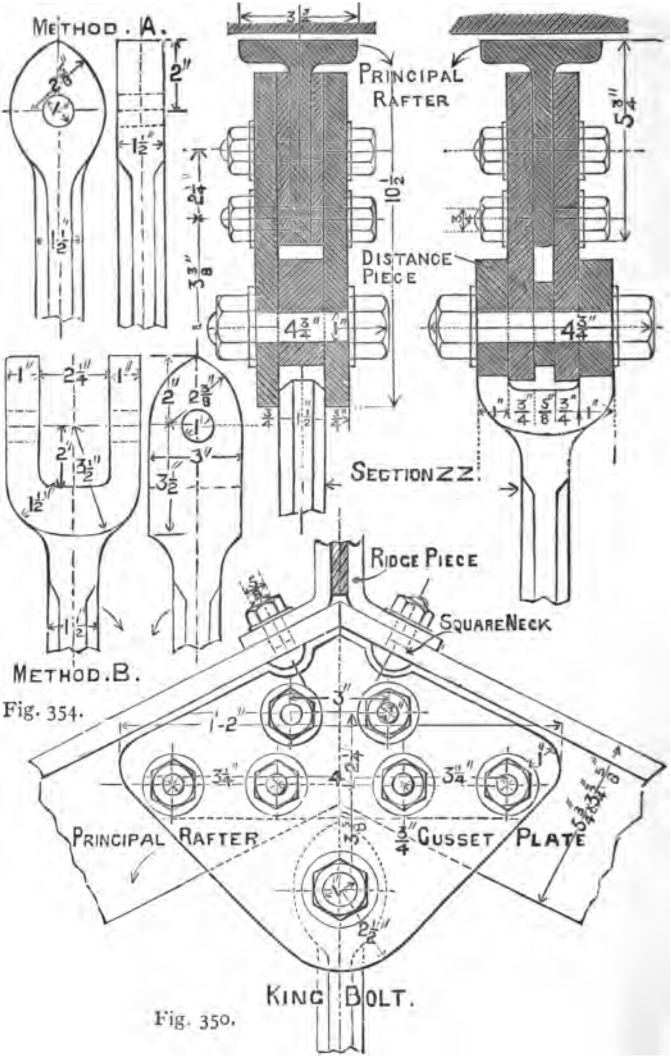


Fig. 354.

Fig. 350.

KING BOLT

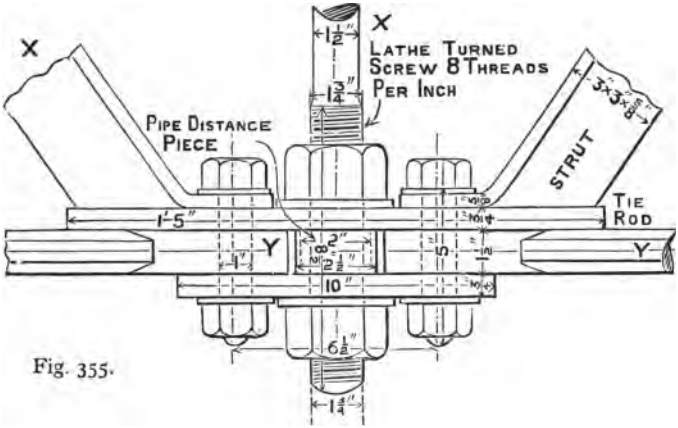


Fig. 355.

TIE ROD BETWEEN PRINCIPALS

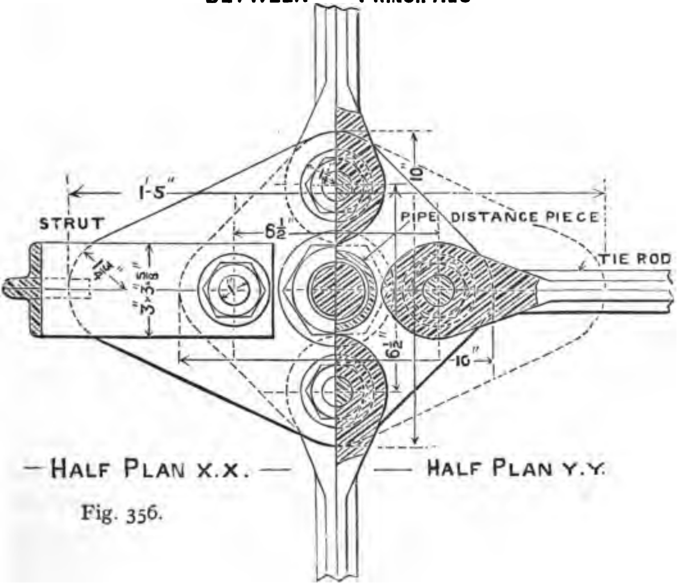


Fig. 356.

move at one end in a horizontal direction to expand and contract under changes of temperature without hindrance.

Junction of Members at Foot of King Bolt.—These may be arranged, as shown in figures 302, by rivetting to cover plates where all the members are of flat iron, or as in figures 355 and 356, which show king bolt, struts, and tie rods, secured by nuts and bolts to junction plates. All trusses to prevent them bulging laterally should be tied together by rods at the feet of king bolts, as shown in figure 356.

Junction at Foot of Strut with Tension and Tie Rod.—This may be constructed with unequal forks to tie rod when in two pieces, strut forked over both, and the whole bolted together, as in figure 318, or horizontal portion of tie rods and lower jaw of tension rods may be forged slightly eccentric and eyes drilled, the strut and lower portion of tie rod forked, and all bolted together, as shown in figure 322; or, as in the example of truss for 50 feet span, figures 355 and 356.

Junction with two Struts and Tie Rod.—This joint often occurs in small trusses about 35 feet span, and may be constructed as in figures 329 and 330.

Junctions at Heads of Principal Rafters.—These may be formed by means of gusset plates:—

(*a*) With tension rods forged flat at end, and eyes drilled, and thickness of web made out with packing pieces, and the whole rivetted or bolted together according to its size, as shown in figures 350 and 351.

(*b*) By forking tension bolts over gusset plates between, consisting of pipe which has distance pieces, the length of which is equal to the thickness of the web of the principal rafter, and the whole is bolted or rivetted together, as shown in figure 352.

Junction of Struts with Principals.—Where cast iron struts are used forks are cast on ends of struts for bolting to principal rafters and tie rods, as shown in figure 325; if flat bar or tee iron is employed for struts, straps are rivetted to each side of the web of the struts to enclose web of principal rafter, to which it is rivetted or bolted. If a tension rod is suspended from this joint it should be forked over, as shown in figures 348 and 349.

Dimensions of Members.—The following dimensions rom actual practice are given in Molesworth's "Pocket Book":—

SCANTLINGS OF IRON ROOFS.—⅕ PITCH.

CAMBER OF TIE ROD = $\frac{\text{SPAN}}{40}$ PRINCIPALS 6 feet 8 inches APART.

Span.	Principal Rafter.	Struts.	King and Queen Bolts. Diam. =			Tie Rod. Diam. =		
Feet.	Tee Iron.	Tee Iron.	*a*	*b.*	*c.*	*d.*	*e.*	*f.*
20	2½ × 2 × ⅜	2 × 2 × ⅜	¾	⅝	—	⅝	¾	—
25	2¾ × 2½ × ⅜	2 × 2 × ⅜	⅞	¾	⅝	⅞	1	—
30	2¾ × 2½ × ½	2½ × 2½ × ⅜	1	¾	⅝	1	1⅛	—
35	3 × 2¾ × ½	2½ × 2½ × ⅜	1	¾	¾	1	1⅛	1¼
40	3½ × 3 × ½	2½ × 2½ × ⅝	1⅛	⅞	¾	1⅛	1¼	1⅜
45	4 × 3½ × ½	3 × 3 × ½	1¼	1	⅞	1¼	1¼	1⅜
50	4 × 3½ × ⅝	3 × 3 × ⅝	1¼	1	⅞	1¼	1⅜	1½
55	5 × 4½ × ⅝	4 × 4 × ½	1⅜	1⅛	1	1⅜	1½	1⅝
60	5 × 4½ × ¾	4 × 4 × ⅝	1⅜	1⅛	1	1½	1⅝	1¾

⅕ PITCH.—CAMBER OF TIE ROD = $\frac{\text{SPAN}}{30}$ (see fig. 298.)

Span.	Principal Rafter—Tee Iron.	*h.*	*j.*	*k.*
20	2½ × 2 × ⅜	⅝	⅞	⅝
25	2¾ × 2 × ⅜	¾	1	¾
30	2¾ × 2½ × ½	2¼ × ¼	2¼ × ⅜	2¼ × ¼
35	3 × 2¾ × ½	2½ × 5/16	2½ × ½	2½ × 5/16
40	3½ × 3 × ½	2½ × ⅜	2½ × ⅝	2½ × ⅜
45	4 × 3½ × ½	3 × ⅜	3 × ½	3 × ⅜

Small Trusses.—Trusses up to 20 feet span are usually made without struts, simply tee iron principal rafters and flat or round iron for tie and king bolts, or with corrugated iron overlapping, and rivetted together in the form of an arch, and prevented from springing by the tie forming the chord of the arch.

Elevation of Trusses.—Up to 30 feet span, trusses may be formed by T iron principals, and flat bar for tensional members, the joints held together by rivetting to cover plates.

Figures 331 to 341 show a method of forming trusses suitable for spans of 40 feet, using round bar iron for tensional members, T iron for principals, and cast or wrought iron of cross section for struts.

Figures 311 to 321 give all necessary details and methods of securing shoes to cast iron staunchions or to stone templates, and method of forming ventilators at apex. The truss for this span is sometimes economically arranged by using two cast iron struts, which are supported at junction of tension and tie rods, and in their turn uphold the principal rafter. Figures 329 and 330 show method of arranging the junction of the five members.

Forty feet to 50 feet spans may be bridged, as illustrated in figures 331 to 341, which is known as the Belgian truss, or, as in figures 342 to 359, which illustrates an English truss, with method of constructing skylight, and obtaining ventilation.

CHAPTER XI.

JOINERY.

Joinery.—This is the art of uniting and framing wood to form the finishings of houses. All the exposed surfaces are usually prepared to take a covering of paint or polish to preserve it from the effects of the atmosphere. The wood employed is called stuff, and comprises battens from 2 to 7 inches in width and ¾ to 3 inches thick, boards 7 to 9 inches wide and 2 to 4½ inches thick, and planks any width above. The operations of joinery include sawing, planing, grooving, rebating, moulding, mitreing, scribing and the construction of joints and frames in such a manner as will allow the wood to shrink and swell without hindrance.

Sawing.—Is the cutting of wood by means of saws. On machines these would be band or circular, but for hand use may be rip, hand, tenon, dovetail, key and fret saws.

Planing.—Is taking shavings off wood by means of planes, and is described as dressed, wrought, which when brought to a level surface is said to be out of winding.

Shooting.—Is planing the edges of boards straight and square with face.

Chamfering.—Is taking the arris or edges off boards; forming a bevil, generally by means of a plane. When two chamfered edges are placed together, as in figure 371, it makes what is known as a V joint.

Rebating.—The planing or cutting away of a rectangular section from the edge of the board.

Scribing.—Is the fitting of boards to irregular surfaces, such as skirting to floors.

Plough Grooving.—Grooves made parallel to edges of boards, with a special tool called a plough.

Cross Grooving.—Is the operation of forming a sinking across the grain, often done with a saw and router, as in the case of housings for risers and treads into strings, or when a groove is sunk entirely across a board by a special plane with cutting teeth, called a grooving plane.

Tongues or Feathers.—Are thin pieces of wood, usually pine veneer cut $\frac{7}{8}$ inch wide, about $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, inserted in plough grooves, to prevent dust, light or air passing through the joint of battens or boards, should the latter shrink. If cut with the grain they are called straight tongues or feathers. Where cut across the grain, they are known as cross tongues or feathers. These are used where considerable shearing resistance is required, as the former under such conditions would split.

Mouldings common to all the Roman orders are eight in number.

(1.) *Fillet or Band.*—Is a flat projection and is the smallest rectangular member employed in the composition of mouldings as at *a*, figure 360.

(2.) *Astragal or Bead.*—Is a moulding of semi-circular section, that is usually worked by the joiner with the aid of special tools called bead planes. They may be divided as bead, bead with quirk, double quirked bead (figure

362), staff return or angle bead (figure 363), cocked bead (figure 365), and when it has its diameter vertical, it is called an astragal, as at *f*, figure 360. Beads are worked at joints, so that if latter opens through shrinkage, the shadow cast may take away the unsightliness of a straight joint, as shown in figure 396.

(3.) *Torus.*—Is a combination of quirked bead with its diameter vertical surmounted by a fillet, as in figure 364.

Fig. 360.

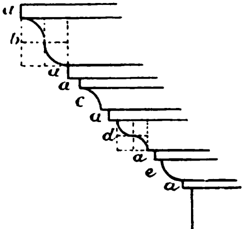
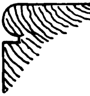


Fig. 361.



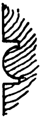


Fig. 362.

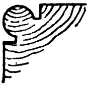


Fig. 363.

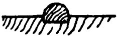


Fig. 365.

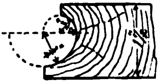


Fig. 366.

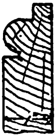


Fig. 364.

(4.) *Ovolo.*—The Roman ovolo shows in section a quarter circle adjoining two square members, as at *e*, figure 360.

(5.) *Cavetto.*—Is the name given to hollow mouldings, as at *c*, figure 360.

(6.) *Cyma recta.*—Is the combination of a concave and convex moulding with adjoining fillets, the hollow part of moulding being uppermost, and is sometimes often called, in the workshop, a lamb's tongue moulding, from its fancied resemblance, shown at *b*, figure 360.

(7.) *Cyma reversa.*—Is a moulding similar to cyma recta, but having the rounded portion uppermost, as at *d*, figure 360.

(8.)—*Scotia.*—A moulding, the section of which is a hollow formed by two quarter circles, as in figure 366.

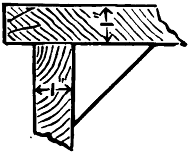


Fig. 367.

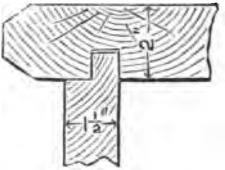


Fig. 368.

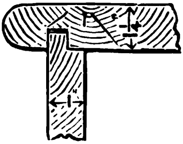


Fig. 369.

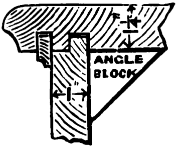


Fig. 370.

Nosings.—Are projecting members of joinery, usually occurring at the intersection of two surfaces, such as window nosings, stair nosings, etc., generally to protect the arris, and to form a finish, and may be square, chamfered, rounded, or moulded, as in figures 367 to 370.

Joints with the Grain.—Plain or square, ploughed or tongued, rebated, rebated and grooved, twice ditto and splayed ditto, and dowelled joints have been described on pages 93 and 94, grooved and tongued and dovetail key.

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Grooved and Tongued.—This is commonly called a matched joint, for the reason that it is often prepared by hand with planes, which form grooves and projections matching or fitting one another, as at *a*, figure 371.

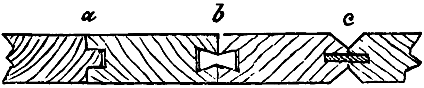


Fig. 371.

Dovetail Keys.—These are generally short lengths of hard wood slips, double dovetail in section, inserted at the ends of joints between thick boards to prevent same starting at ends, as at *b*, figure 371.

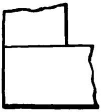


Fig. 372.

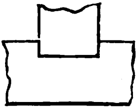


Fig. 373.

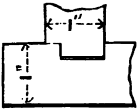


Fig. 374.

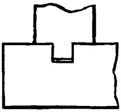


Fig. 375.

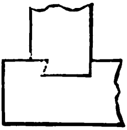


Fig. 376.

Angle Joints Crossing the Grain.—Butt, housing, single shoulder and tongue, and dovetail, as illustrated in figures 372 to 376, are joints used at angles where ends may be left projecting, and all but the dovetail (which is slightly taper in its length to tighten as it is fitted in), depends on nails, screws, or wedging for the fixing.

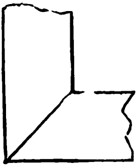


Fig. 377.

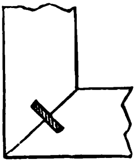


Fig. 378.

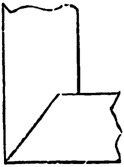


Fig. 379.

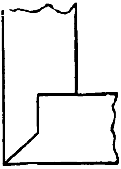


Fig. 380.

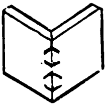


Fig. 381.

Figure 377 shows a plain mitre, usually secured by glue and brads. Figures 378 show a feather introduced to strengthen the joint. Mitre and butt, figure 379, is applicable for boards of varying thicknesses. Mitre and rebate enables mitre to be fixed easily, as in figure 380, the rebate of which forms a good abutment. To avoid the use of nails, keyed mitres are used, as in figure 381, for interior angles, the keys consisting of pieces of thin veneer inserted in saw cuts forming dovetails. Common dovetails, as in figure 382, are used when the exposed end grain is no disadvantage, as in cisterns. Lap dovetails are used for drawer fronts, as shown in figure 383, which shows end grain on sides only.

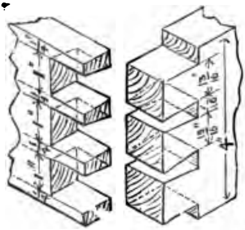


Fig. 382.

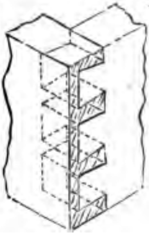


Fig. 383.

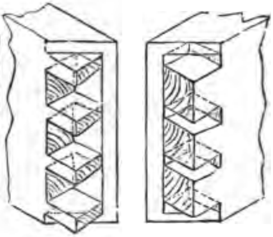


Fig. 384.

Secret dovetailing, as in figure 384, is sometimes resorted to when no end grain is desired to be exposed. Figures 250, 251, and 377 to 380 show six methods of forming angle joints, for framings, linings, casings, etc., the joints being arranged to hide the end grain of both pieces.

Wide Surfaces prevented from Warping.—When large wood surfaces, such as dado panels, are required to be kept in one plane, and yet allowed to shrink or swell without hindrance, a key may be inserted in a dovetail-shaped groove, sunk at back to receive same. The key should be taper in its length to admit tightening up, as in figure 385, or a slot and screw joint may be made, which consists of battens crossing the surface and fixed in centre, on either side of which elliptical-shaped holes are cut to admit the screws which are inserted, moving freely as the wood expands or contracts, figure 386, or battens may be ploughed and buttons may be used, as in figure 387.

Wide panels, mantel and fascia boards are often bored either right or nearly across their width and iron bars inserted, slightly less in diameter than the bore.

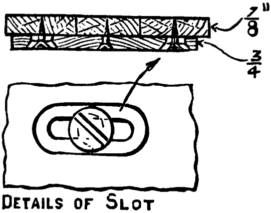
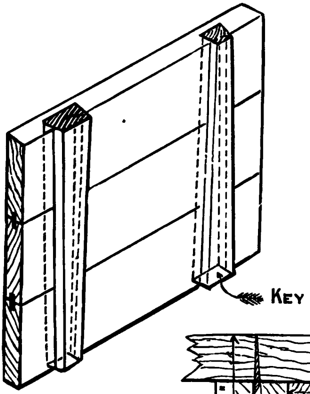


Fig. 386.



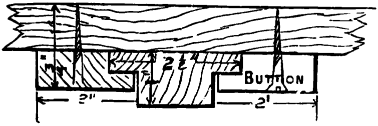


Fig. 385. Fig. 387.

Mortise and Tenon.—A description of the same has been given on page 72. In joiners' work the best proportion for the thickness of the tenons is ⅓ that of the stuff, and the width of tenons four times their thickness, the maximum width not exceeding two inches.

Haunchion—Consists of a stump tenon, usually ½ inch long, adjoining the tenon proper, fitting into a groove cut to receive it, as in figure 388, to prevent the tenoned piece twisting. The shortness of the haunchion adds great strength to the root of the tenon, about which, but for the haunchion, it would often snap when exposed to sudden shocks. The roots of tenons in thick stuff are sometimes also assisted to resist stress by cross tongues, as in figure 389.

Double Tenons.—In wide rails it is usual to cut two tenons, with haunchion between, for the reasons of drawing shoulder up more closely, and to prevent any tendency of the rail to twist. Care must be taken in wedging not to split the rail by driving in the two inner wedges, marked BB in figure 408, before the outer ones. It does not always split at the time, but afterwards, when combined with any shrinkage of rail that may occur between the tenons. The shrinkage of rail between the tenons is

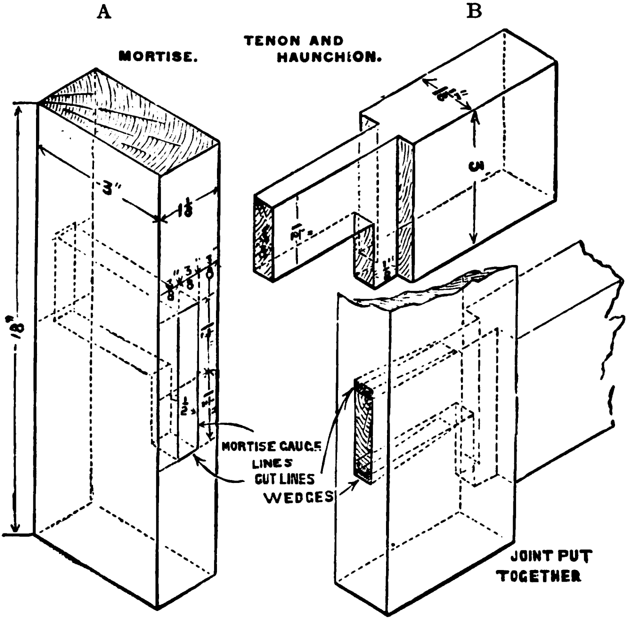


Fig. 388.

a disadvantage common to all double tenons, and some propose to have only one tenon, as is usually adopted for rails up to 6 inches wide, with haunchion on each side, as in figure 402, but double tenons have been found to answer their purpose without splitting through shrinkage, if the material has been well seasoned, and the outer wedges, marked AA, are driven to crush the fibres of rail more closely together, the wedges BB being gently forced in simultaneously, to prevent the tenons snapping across at their roots.

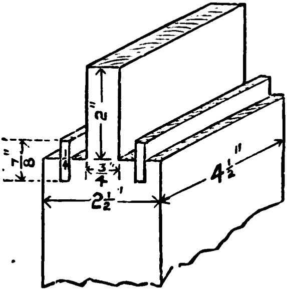


Fig. 389.

Wedges—Should be made to "bite" well at their points or smaller ends, for this reason, that if the style shrinks it may do so towards the shoulder, and not away from it, the latter presenting the appearance of the framing falling to pieces.

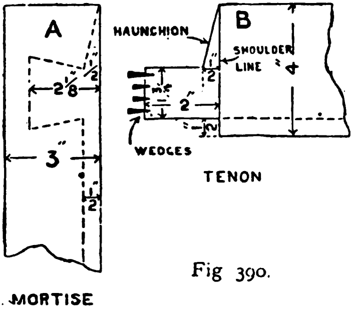


Fig 390.

Fox-tail Wedging. — Used in very good work, as described on page 76, and possesses the advantages of allowing style to shrink towards shoulder, and not exposing end grain of tenon. See figure 390.

Framings—Are constructed of narrow pieces of wood, forming the boundaries and divisions of spaces to be enclosed, generally secured together by the mortise and tenon joint. The vertical pieces of framings are usually mortised, and called styles; the horizontal members are tenoned, and are known as rails. The dividing pieces are usually parallel with styles, are named muntins, and the interior closed up, generally by thinner pieces of wood, which are called panels, fitting into plough grooves about ½ inch deep, loosely but without rattling, so as to admit of the panel moving in the groove when it shrinks, otherwise, if the edges are held fast by tightly fitting grooves, the panel is likely to split down its centre.

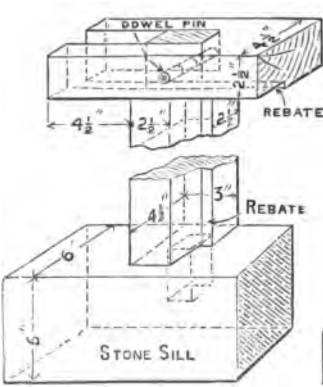


Fig. 391.

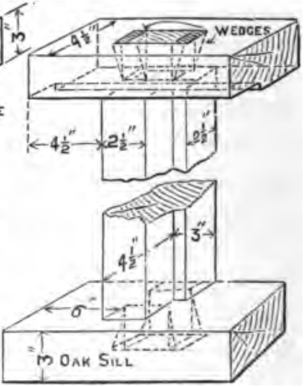


Fig. 392.

Method of Glueing up Framing.—When all the members have been prepared and fitted, the framing is laid upon bearers (the upper surfaces of which are fixed "out of winding"), and pulled up with an iron cramp, all the tenons and shoulders being coated with hot glue; it is then secured by wedges, dowel pins, or wedges and dowel pins combined, which have been dipped in hot glue. In frames for exterior work white lead is used instead of glue, and dowels are often employed, especially where mortises or slots are cut with a saw, as in figure 391.

Solid Frames—Are used for doors and window openings, and consist of posts, heads and sills, and are sometimes divided by horizontal members called transoms, and vertical pieces known as mullions. The posts and heads are generally bedded against plaster screeds worked against brickwork to prevent wind and rain from entering at those joints, and to reduce the vibration caused by opening and closing doors and windows. The joints occurring between frames and stonework are usually pointed only.

Solid Door Frames—Consist generally of two posts tenoned to head, which may be left projecting about 4½ inches, and built into wall. The feet of posts may be joggled to stone sills, as in figure 391. Sometimes instead of a joggle an iron dowel, about 3 inches long and 1 inch square, is used; better still cast iron shoes, about ⅜ inch thick and 4 inches deep with a joggle, are made to enclose the feet, the shoes are sunk flush in the sides of the posts and the joggle in the sill.

Solid Window Frames.—These are used for fixed sashes, casement sashes, and sashes hung on centres. These frames always include head, posts, and sills (except in the circular form); the heads and sills are usually cut between the brickwork or masonry, and fixed by folding wedges, as shown in figure 414. Water is prevented from passing through stone and oak sills by a metal water bar inserted in plough grooves sunk to receive it, as in figure 420.

Panelling. — The boarding that fills up the interior spaces of framing is called panelling, and fits into grooves so that it may contract or expand freely, and may be as a flat, flush, or raised panel on one or both faces.

Flat Panels.—Figure 393 shows what is known as a flat and square panel, figure 394, flat and moulded. Sometimes, instead of moulding being stuck on style, it is planted on, but this is inferior work.

Flush Panels.—Where a panel has both surfaces flush with the framing, as in figure 395, it is said to be a solid panel. Figure 396 shows a flush panel on one side only. Where beads are stuck on the vertical edges of panels only, the panel is known as the bead and butt, as in figure 408, but when all the four edges of a panel show beads stuck or planted on, it is called bead and flush. The beads crossing the grain of the panels are usually planted on. This does not allow the panel to shrink without splitting, and is therefore inferior work. A better method would be to stick the beads on the edges of rails and styles.

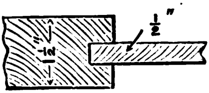


Fig. 393.

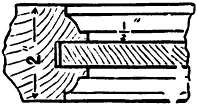


Fig. 394.

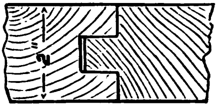


Fig. 395.

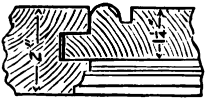


Fig. 396.

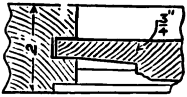


Fig. 397.

Raised Panels.—Panels sunk at edges to fit into the grooves present a raised appearance, as shown in figure 397, and are called raised panels.

Chamfered Panels.—Are panels made of narrow battens, chamfered on edge, and together forming a V joint, as at *c*, figure 371. The battens are sometimes cut and arranged diagonally, as in figure 412.

Doors.—These may be divided as ledged, ledged and braced, framed and braced, and framed and panelled doors.

Ledge Doors.—Consist of a number of vertical battens, fixed by wrought iron nails, driven in from the face of battens, and clenched to horizontal rails or ledges This is the commonest description of door, and is used for

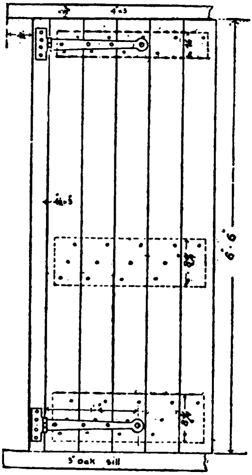


Fig. 398

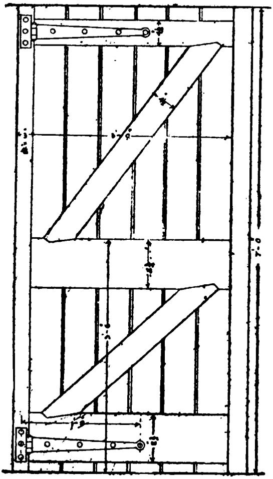


Fig. 400.

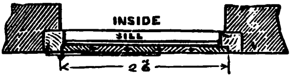


Fig 399.

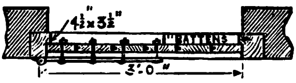
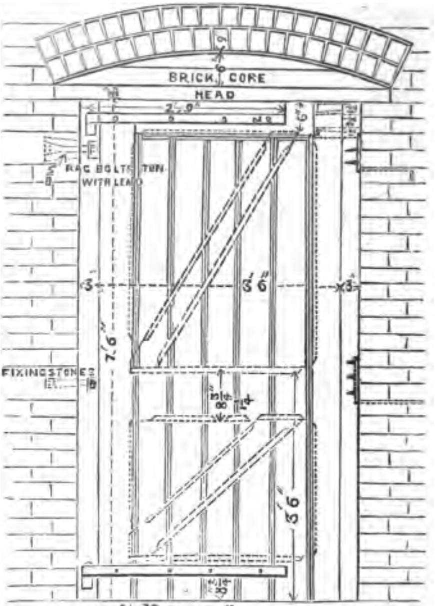


Fig 401.

temporary purposes, outhouses, &c. The battens may be square, ploughed and tongued, grooved and tongued, or chamfered, and are generally fixed to posts by cross garnets or strap hinges with screws.

Ledged and Braced.—Are doors made in a similar manner to the ledged doors, but having in addition braces, which stiffen the doors and keep the same from dropping at their free edge; the lower end of braces should always be near the supported edge. The joint with a brace and rail is generally made as in figure 400, which shows the battens

Fig. 402.



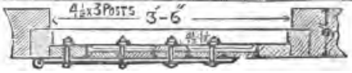


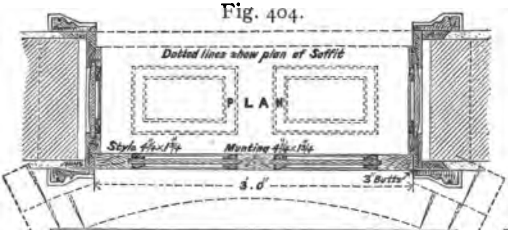
Fig. 403.

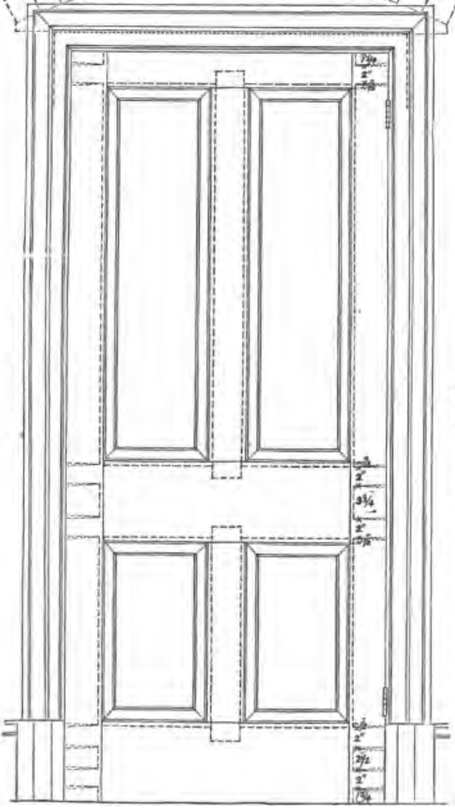
grooved, tongued, and beaded, and hung by cross garnet hinges.

Framed and Braced Doors.—These are a good and strong form of door, and extensively used for external work to withstand rough wear. A framing is made, styles and top rail being of equal thickness, bottom and middle rails with

4-Panel Internal Door and Finishings.

Fig. 404.





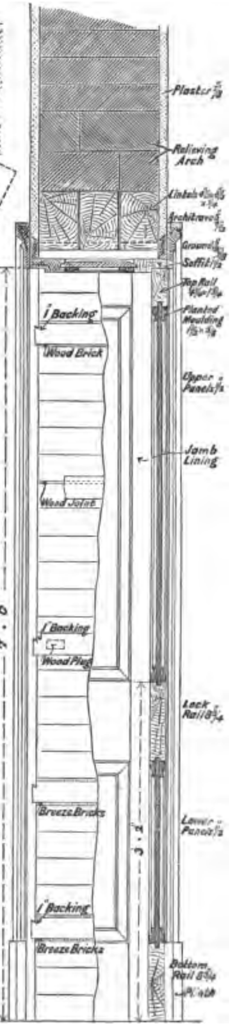


Fig. 405.—Elevation.

Fig. 406.—Section.

the braces having a thickness equal to the styles, minus the thickness of battens, all members flush on the back. The bottom and middle rails are cut with barefaced tenons, and the braces may be stub-tenoned into rails and styles, as in figure 403. The battens are then pushed into their position, and secured to rails and braces by wrought-iron nails hammered in from the face and clenched at the back. The battens extend from top rail to the ground, more effectively to let any water drain off the door that might fall upon it. Hook and eye hinges are suitable for hanging these doors.

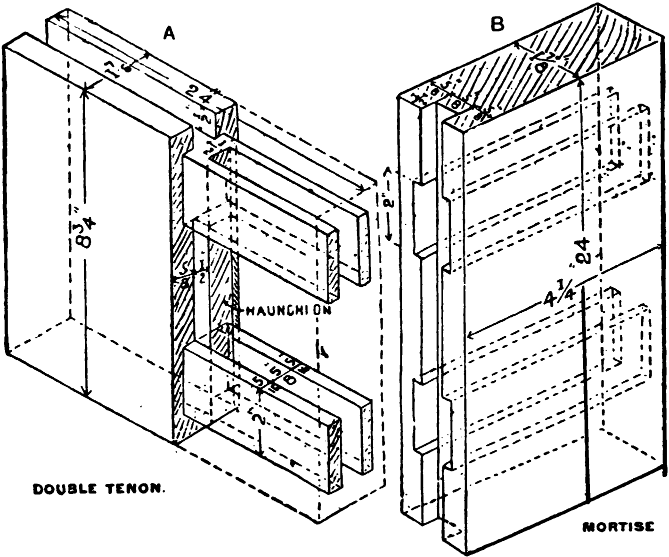


Fig. 407.

Framed and Panelled Doors.—These are described by the number of panels they contain, and consist of styles, rails, muntins and panels.

Four-panel Doors.—Figure 405 shows a four-panel door

7 feet high, 3 feet wide, and finishings for same, with all the necessary dimensions. The height of the top line of middle or lock rail is usually between 3 feet 2 inches and 3 feet 6 inches, so that the handle of door coming in the centre of lock rail may be a convenient height. Doors are usually hung on butts, as in figures 405 and 410.

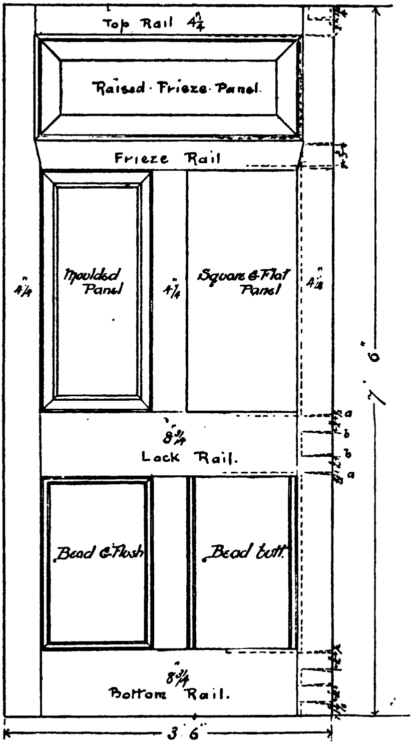


Fig. 408.

Lock Rail.—To receive mortise locks, the tenons are constructed, as shown in figure 407, so that the mortise for lock may come between the tenons, and not weaken or destroy the wedges that fix the tenons, which would happen if styles were mortised for locks, and the rails tenoned in the ordinary way. The joint is better and more economically made when the width of the haunchion is the sum of the thickness of the two tenons plus the space between.

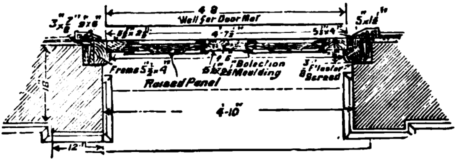
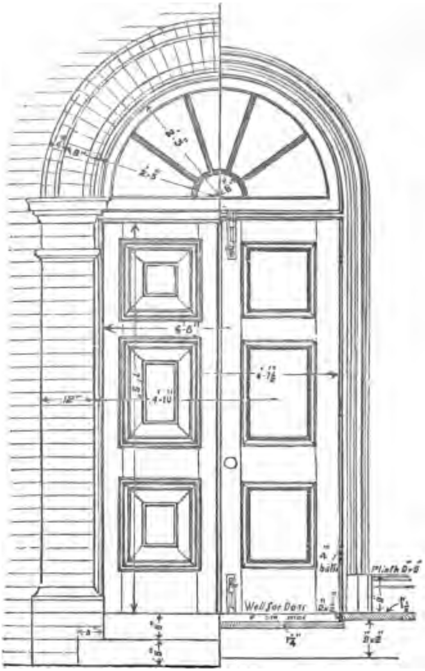


Fig. 409.



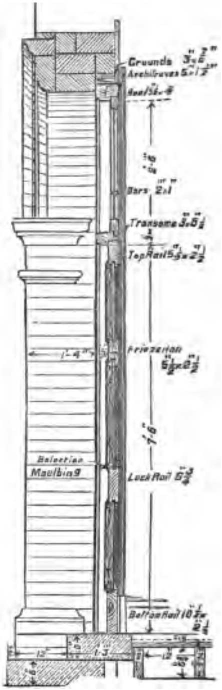


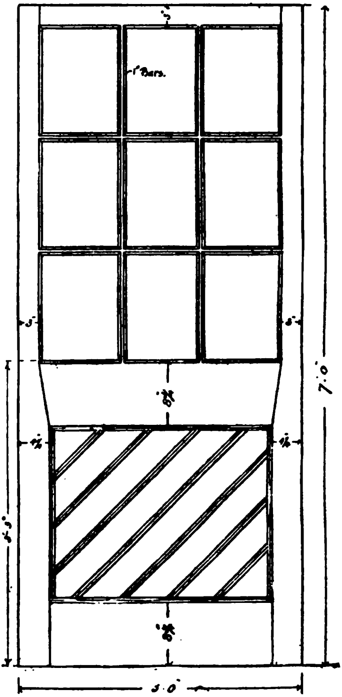
Fig. 410. Fig. 411.

Five-panel Doors. — Doors 7 feet high and over that height are often divided into more than four panels, and the rail, between top and lock rails, is called a frieze rail, and the top panel a frieze panel, as in figure 408.

Folding Doors.—A pair of doors hanging one on each door jamb or post, is described as folding doors, as in entrance doors, as shown in figures 409 to 411, or as in partitions.

Sash Doors.—Are doors, the upper part of which are arranged for glass panel or panels, the styles of which are sometimes narrower at their upper part to gain more light, and are called diminished styles, as in figure 412.

Fig. 412.



Sashes. — Are frames formed of styles, rails, and bars, which are rebated to receive glass panels, and the wood members may be plain, chamfered or moulded. The rails are tenoned to the styles, and ends of bars may be tenoned to styles, rails or bars, or where intersecting another bar may be scribed and dowelled, as shown in figure 413. The through bars of sashes should be those in the direc-

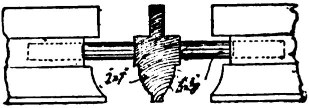


Fig. 413.

tion of the impact or stress. In double hung sashes and those hung on centres the through bars would be vertical, in casement sashes would be horizontal.

Sashes hung on Centres.—For factories, stables, lantern lights, and other positions, where economy is an object, or in positions that would be inconvenient to be hung with weights on cords, sashes hung on centres in solid frames are employed, and are especially suitable to obtain light and air in high positions that are not easy of access, as these sashes are hung on iron centres or pivots, higher up than their centres of gravity to allow for the weight of the

Fig. 415.

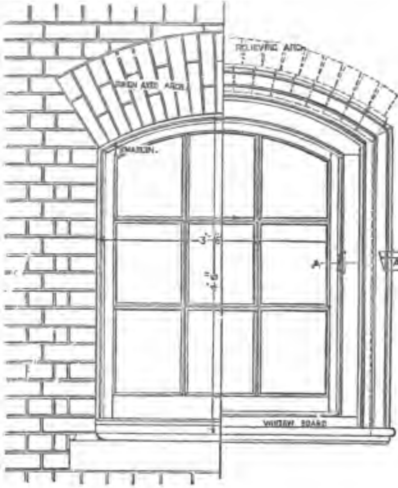
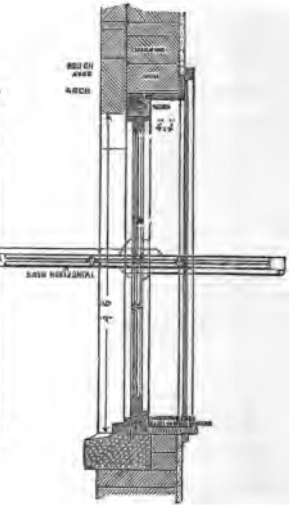


Fig. 416.



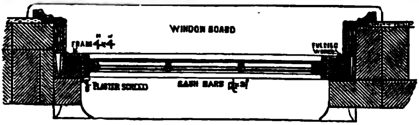


Fig. 414.

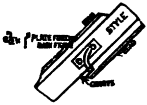


Fig. 417.

cord attached to it, so that the window may be closed by its own weight from below by simply taking the cord off the belaying pin on which it is usually wound. These sashes require carefully fitting and the beads cut as in figure 416, otherwise the wind and rain will find a passage through the space between beads fixed on the sashes and the frames, and to admit sash being taken out grooves are sunk in beads, as shown in figure 416.

Sometimes the outside edge of the style is plough grooved so that when the sash is opened horizontally it may be taken out of the frame. This avoids the grooving of the beads that are fixed on the sashes, and, if the groove on the edge is no objection, greatly simplifies the work.

Sliding Sashes.—Are said to be single hung when one sash is fixed, or without cords, weights, and axle pulleys, and the other is hung by the latter.

Double hung sashes is the name applied when both frames are suspende by cords, weights, and axle pulleys, fig. 419.

Double Hung Sashes and Cased Frames.—Usually in dwelling-houses this method is adopted, owing to the efficiency in keeping out the weather, the ease with which the sashes can be raised or lowered, and the small amount of space occupied and required for working. The frames are made of linings enclosing a space (for the weights to move up and down, which balance the sashes), and consist of pulley styles, pulley head, oak sill, inside and outside linings, parting bead, inside bead, parting slip, back linings, angle blocks, brass axle pulleys, and are known as cased frames or boxings. There are two sashes, top and bottom, which consist of top and bottom rails, meeting rails, styles and bars, which are suspended by cords and weights. Figure 419 shows an opening

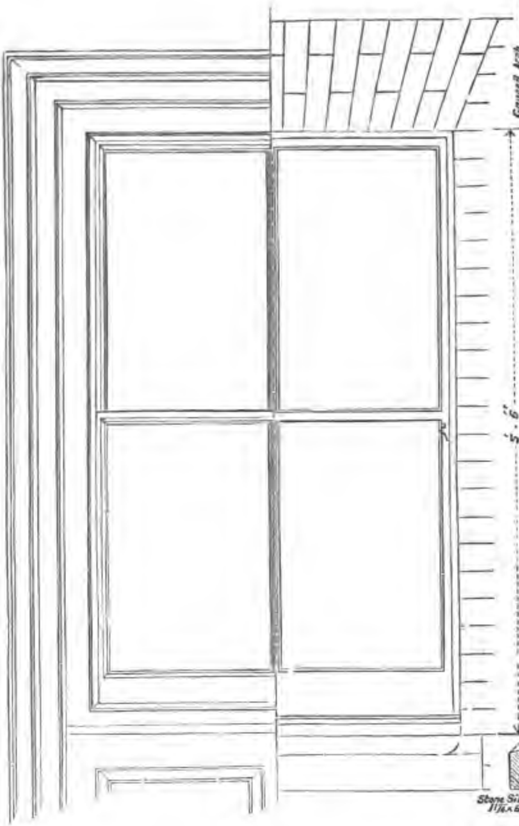


Fig. 419.

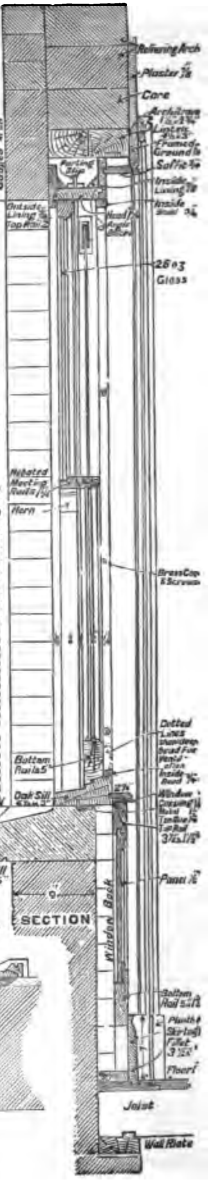


Fig. 420.

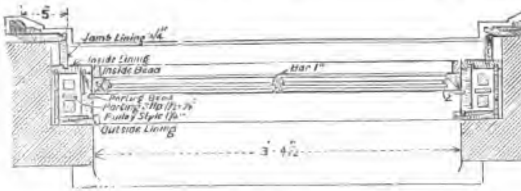


Fig. 418.

Fig. 423.

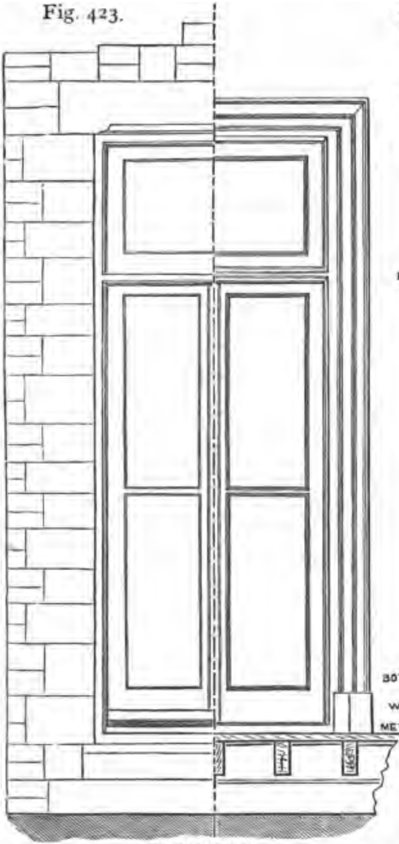
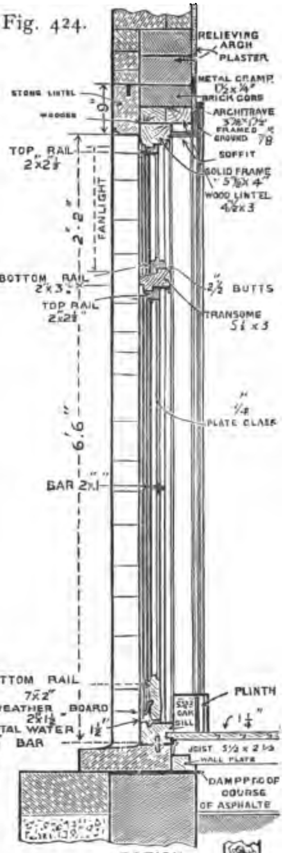


Fig. 424.



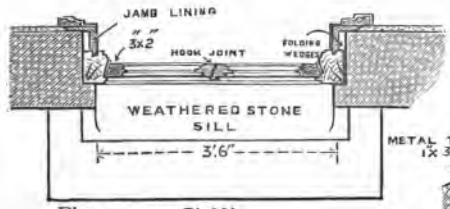


Fig. 422. PLAN.

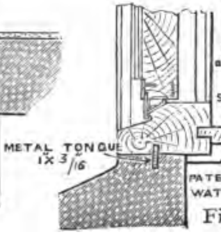


Fig. 425.

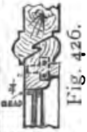


Fig. 426.

filled in with double hung sashes and cased frame, having rebated meeting rails, to prevent sash fastener being opened from outside, a deep bead shown in section by dotted lines, to allow bottom sash to be raised about two inches so as to admit air without draught, and the vertical sash beads fixed by screws in cups to allow them to be taken off and re-fixed for repairs or window cleaning, without any damage to bead or frame.

Casement Sashes and Frames.—When sashes are hung by one of their vertical edges, they are called casement sashes. It is a method most commonly employed on the Continent, they are convenient to obtain access to roof. The sashes and frames may be constructed to open outwards or inwards.

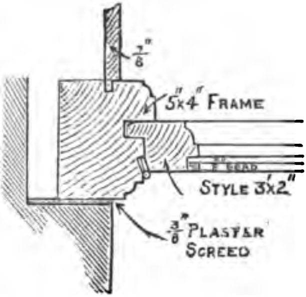


Fig. 421.

Sashes opening outwards present no great difficulty in obtaining watertight joints, but have this objection that if a sash should happen to be left open, without being secured, the wind may act upon it and smash the glass, which in high situations would be dangerous. The joints in sashes opening inwards are very difficult to get wind and watertight, and but for this objection would undoubtedly be more frequently used, as they possess the advantage of being much easier to clean than any other method of fixing sashes, and the danger consequent thereon is reduced to a minimum.

Sashes opening outwards.—The members of frames which are all solid are rebated from the outside, as in figure 421.

Sashes opening inwards.—Figures 422 to 426 give an illustration of a pair of casement sashes, opening inwards, in solid frames, showing a metal water bar on bottom rails, and is very effectual in withstanding a driving rain at the seaside, or in places exposed to the weather this becomes a necessity; in sheltered situations a wood water bar, as in figure 425, may be used. The outer meeting style has a projecting moulding worked on it, or in inferior work this may be planted on, to protect the vertical joints between meeting styles. The hanging styles have a tongue worked on to fit into grooves sunk in the posts, and they are secured on the inside by bolts. Sometimes an espagnolette bolt is employed, which combines handle, top and bottom bolts, and the sash may be loosened or closed by one turn of the handle.

CHAPTER XII.

PLUMBING.

Coverings.—The external work of a plumber chiefly consists in making exposed surfaces on roofs watertight. This he contrives to do by means of sheet lead, which, laid successfully, far surpasses for flats, gutters, flashings, &c., any other material, and combines lasting and waterproof properties. Lead coverings in towns may be said to be more economical than zinc. Zinc lasts well in the pure air of the country, but when exposed to the deleterious effects of the sea air, or the atmosphere of large towns, is readily destroyed.

Lead, as used by the plumber for external work, is obtainable in two forms, cast and milled.

Cast Lead.—The lead is melted and cast into moulds in sheets of the required size, but may be obtained up to 20 feet in length and 7 feet in width. It is very durable under great changes of temperature, and, being very hard, is suitable to positions where subjected to traffic, but it is subject to flaws and sand holes.

Milled Lead.—Sheets of lead are cast and passed through rollers; it may be obtained in lengths of 35 feet and widths up to 9 feet. It is more uniform in thickness than cast lead, and is better adapted for works where much bending and bossing is required to be done; it is not subject to the sand holes and flaws as is cast lead, but is not nearly so durable for roof coverings, nor is its resistance to wear equal to cast lead.

Laying Sheet Lead.—The ground to receive sheet lead, which is usually boarding, should be perfectly flat, and all the joints should be traversed by a plane to take away any projecting arrises, preventing any unsightly ridges which otherwise, sooner or later, show through the lead, and which appear so unmistakably after wet weather. No sharp angles should be allowed, but all projections should be rounded off. The grain of the boarding on flats and gutters should always be in the direction of the current.

The soles of gutters are recommended to be formed by narrow boards 4½ inches wide, nailed with the heart side of boards upwards, so that the edges will press tightly against the bearers if the boards cast; the boards should be well nailed about 1¼ inches from both edges. The width of joints caused by shrinkage is obviously much less in narrow than in wide battens.

Care must be taken in fixing sheet lead that it is free to contract or expand, or that the pieces used are of such dimensions that the contraction or expansion will be unappreciable; this is practically satisfied at ordinary temperatures when the lengths of the pieces do not exceed 7 feet. The joints made by the free edges of lead must be so arranged that no water can pass through, or so that the wind is not likely to blow the covering up. If the above conditions are not taken into consideration in the fixing of sheet lead, the force of expansion and contraction will cause it to break away from its fixings, if it be in inclined positions, and form defective places, or to buckle and rise in the centre if it be on a flat.

The following table states the expansion by heat of the metals mostly used in construction, due to heat between the temperature of 32° and 212° Fahr. To find

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the expansion due to an alteration of temperature of one degree, divide the tabulated number by 180:—

Cast Iron	1 part in 889
Wrought Iron	1 ,, 819
Steel, Untempered	1 ,, 927
Steel, Tempered	1 ,, 807
Lead	1 ,, 349
Zinc	1 ,, 340

The following are the weights of lead recommended for the various parts of external coverings:—

Roofs, Flats, and Main Gutters ..	7 lb. lead
Hips, Ridges, and Small Gutters ..	6 lb. ,,
Flashings	5 lb. ,,
Cisterns and Sinks, bottom	7 lb. ,,
,, ,, sides	6 lb. ,,
Soil Pipes	8 lb. ,,

It is important that the lengths of lead for any of the above purposes should not be greater than 7 feet.

Lead is usually described and specified by its weight in lbs. per superficial foot. The following table gives the thickness of milled lead in common use. The thickness, it may be noticed, is 17 thousandths of the inch for each lb. per superficial foot:—

Weight in lbs. per foot super.	Thickness in inches.	Weight in lbs. per foot super.	Thickness in inches.
1	0·017	7	0·118
2	0·034	8	0·135
3	0·051	9	0·152
4	0·068	10	0·169
5	0·085	11	0·186
6	0·101	12	0·203

The lengths of pieces of lead usually used in practice for gutters or flats should not be more than 7 feet, and the fall or inclination of the gutters should not be less than 1 inch in each sheet or 7 feet length. Cover and step flashings should not exceed 6 feet in length, and ridge pieces not more than 7 feet. Dormer cheeks when very large should be put on in two or more pieces. Large dormer tops should have a roll fixed upon them, but for small ones the lead has room to expand over the edges.

Nailing should not be resorted to more than is absolutely necessary. Bossing—that is working the lead to the required angular form with box-wood dressers—is preferable to soldering in angles, such as the returned ends of gutters, drips, cesspools, the junction of ridges with brick walls, and in any position where the perpendicular part does not exceed 12 inches in depth. Soldering is very subject to cracking.

Lead Tacks.—These are narrow strips of lead from 1 to 2 inches in width for the purpose of fastening the free edges of flashings, ridge coverings, apron pieces, etc. They are sometimes termed *tingles.*

Passings.—Are the distances pieces of lead lap over the adjoining continuing pieces, and occur in aprons for gutters, stepped flashings, ridge coverings, and in similar situations, wherever it would be unwise to have the lead in one continuous length. The usual length is 4 inches.

Raglets.—Are the grooves or chases in brick or stone walls, usually 1½ inches deep, to receive the turned-in edge of the lead flashings.

Fixing for Flashings.—A small slightly inclined fillet of cement should be made on the lower surface of raglet, the lead flashing secured in same by lead wedges varying from 3 to 9 inches apart, and the open joint between the wedges pointed in cement.

Cover Flashings.—Is the name given to the lead coverings over the turned-up parts of lead gutters or flats, and are usually about 6 inches wide, the object being to keep the part watertight and to allow the covered sheet freedom to contract or expand.

Apron Pieces.—Is the name applied to the lower horizontal flashing of a chimney shaft or wall penetrating a roof, as shown in figures 447 to 450.

Tilting Fillets.—Fillets usually of wood and triangular in section. These are used where the inclined surfaces abut against walls, to tilt the slates, and so carry water away from this weak part, which is usually protected and covered with lead flashings, as shown in figure 452. These fillets are also fixed under the eaves course of slates, so that they may lie close, and thus prevent the wind getting under them, as shown in figure 277.

Cement Fillets.—To save the expense of lead flashings, fillets composed of equal portions of Portland cement and sand are run along the junction of lean-to roofs with walls, but as the cement sometimes shrinks, or breaks away, resulting in an open joint, consequently they fail to answer the purpose for which they are intended.

Joints.—The joints most extensively used for lead coverings for external work may be classified as follows :—

Joints across the Flow or Current.—Lap and drip joints.

Joints parallel with the Flow.—Rolls, hollow rolls, and seams or welts.

Lap Joints.—These are used where the inclined surfaces of pitched roofs are covered with lead. The boarding should be placed at right angles to the inclination. The sheets of lead should be fixed between rolls, the upper sides being turned over the edge of boarding and nailed so that the sheet is secured along the entire length of the top edge; this effectually resists the tendency to crawl down the slope and become detached, as is the case where only nailed to the boarding. The lower edge of upper sheet is made to lap over the top edge of the lower; if the covering is on a vertical surface, as shown in figure 427, a 4 inch lap would be sufficient; but if the surface has an inclination of not less than 45°, a 6 inch lap would be necessary. When inclined at less than 45° the lap would require to be increased considerably, or a drip would have to be formed.

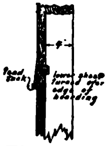


Fig. 427.

Drips.—Flat roofs and gutters are constructed of a number of plane surfaces slightly inclined and raised a short distance one above the other, forming, when finished, a number of low steps called drips, which should not be at greater distance than 7 feet apart. Drips should be made 3 inches in depth, as shown in figure 428, when they are sufficient to overcome the power of capillary attraction; but when made 2 inches or less,

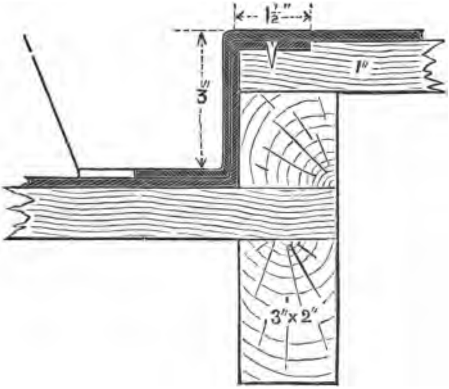


Fig. 428.

they should have a groove formed, as shown in figure 429, to resist that force. For economical reasons drips in gutters are often made not more than 2 inches deep.

Rolls.—On flats or at the ridge of two opposite slopes of gutter or roof, wooden rolls from 1¾ inch diameter and upwards, are fixed at the joint. Sheet lead is dressed round the roll and well into the angles to obtain a firm grip, as in figure 431. Some authorities recommend the joint to be made as in figure 430, the overcloak being cut off, as shown, to prevent capillary attraction, but this is far from being a good plan to adopt. Any traffic on the flat, or change of temperature, is likely to tear up or open the free edges, marked C. The section shown in figure 431 is the better way of constructing these, as the lead is not materially altered by change of temperature, if the

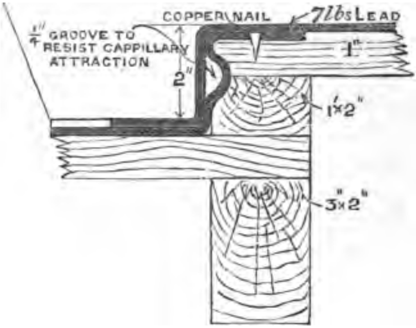


Fig. 429.

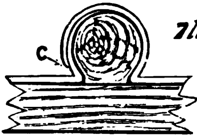


Fig. 430.

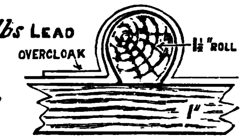


Fig. 431.

lengths used do not exceed the tabulated dimensions and is well adapted to withstand any walking upon it when repairs have to be made to the roof.

Hollow Rolls.—The method of forming rolls without a wooden core has been very extensively used on large buildings, cathedrals and abbeys, especially on those that were built in the mediæval ages.

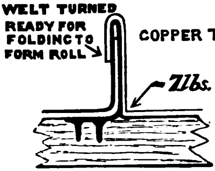


Fig. 432.

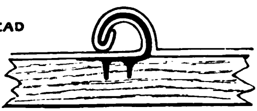


Fig. 433.

To make a hollow roll, a copper or lead tack, about 6 inches long and 2 inches wide, is secured by two screws to the boarding, about every 2 feet apart, the lead is turned up, as shown in section figure 432, and is then ready to be folded over. It is then dressed to enclose a hollow, as in section figure 433. This is a good method of forming rolls, but not suitable for positions where any traffic is likely to come upon it.

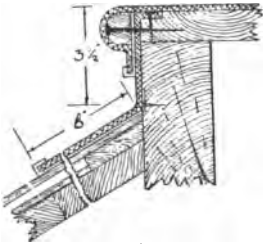


Fig. 434.

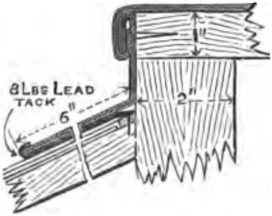
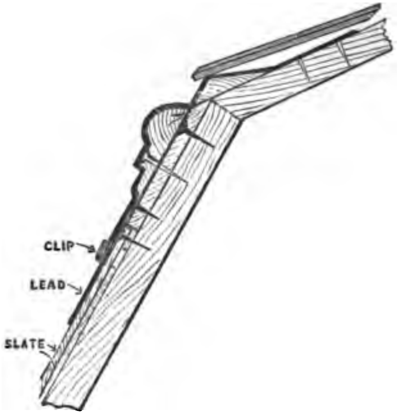


Fig. 437.

Nosings.—At the boundaries of flats adjoining sloping roofs, or at the intersection of two differently inclined surfaces, as at the curb of a mansard roof, the lead covering may be terminated as a nosing, the object being to secure the edges of the lead and yet allow it to shrink or expand freely. Figure 434 shows a flashing of 6 lbs. lead laid on slates, and dressed against the vertical boundary of flat. A wood nosing is nailed over the top edge of the lead, thus firmly securing the flashing, and the lead covering of flat is then dressed round the nosing. The lower edge of flashing is secured from being torn up by the wind by means of lead tacks, thus avoiding the necessity of soldered dots, and admitting of the flashing expanding and contracting.



. 436.

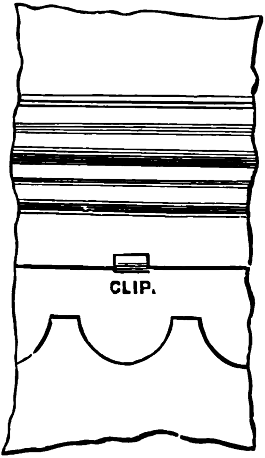


Fig. 435.

Figure 437 shows a flashing secured by copper nails instead of being covered by a wood nosing, and flat welted nosing is formed as shown in the figure.

Figure 435 is an elevation, and 436 a section showing the method of forming nosing for the curb of a mansard roof.

Seams.—The joints with the current on vertical surfaces, may be constructed as flat welts or seams, which consists in fixing lead or copper tacks about every 2 feet apart at the junction of the lead sheets, the edges are bent up and turned over together, and then dressed flat, as shown in figures 438 and 439. For flat pitched, or horizontal surfaces, seams are not so good as rolls.

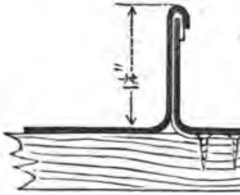


Fig. 438.

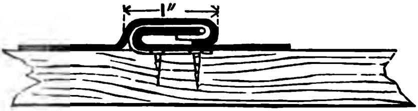


Fig. 439.

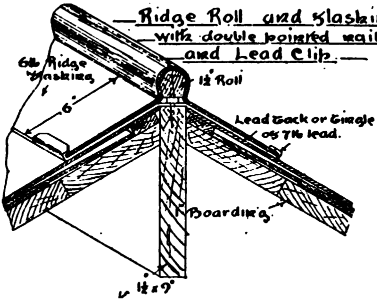


Fig. 440.

Welt.—When two thicknesses of lead are turned over and folded down together, they are said to form a welt, as in figure 439.

Ridge Coverings.—Six lbs. lead is the thickness usually adopted for ridge coverings; the lengths of the pieces should not exceed 7 feet.

The lead should be dressed over a wood ridge roll, which should not be less than 2 inches in height, and may be fixed in one of two ways: First, by double-headed nails, in which case the lead tacks that support the lower edge of ridge coverings, pass beneath the roll and is secured by it, as shown in figure 440; secondly, it may be nailed to the ridge, as shown in figure 441, the lead tacks being secured to the tilting fillet of the last

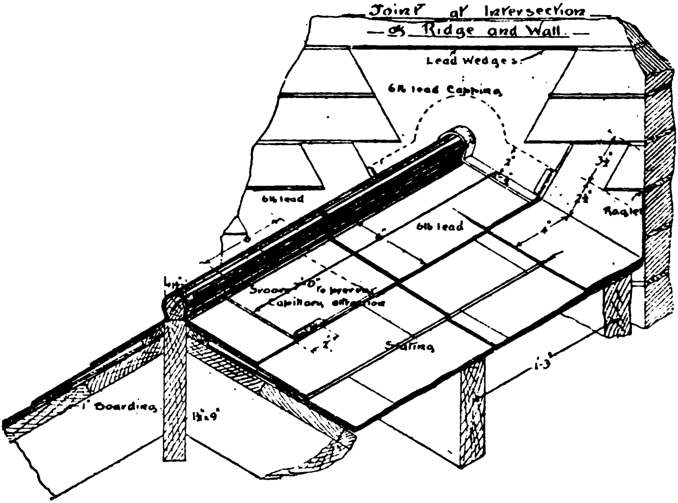
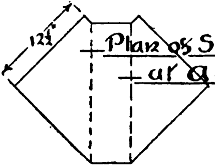


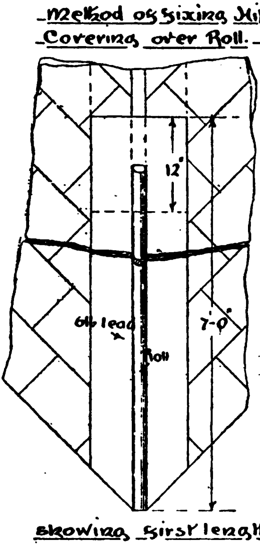
Fig. 441.

course of slates. The lead covering should be dressed well into the bottom edges of the roll, and should extend for 6 inches down the slope on either side of ridge, the free edge being secured by the lead tacks.

A lap joint is formed at the junction of the ridge pieces. This has been objected to by some on the grounds that water is liable to be drawn between the sheets by capillarity or driven in by wind; and if the ridge be not perfectly level, would drain in at that part. These objections may be obviated by forming a groove over the ridge roll, as shown in figure 441, the under piece of lead being dressed into it. Any water finding its way between the sheets on the sloping surfaces would fall on the slates and drain off.

Fig. 444.





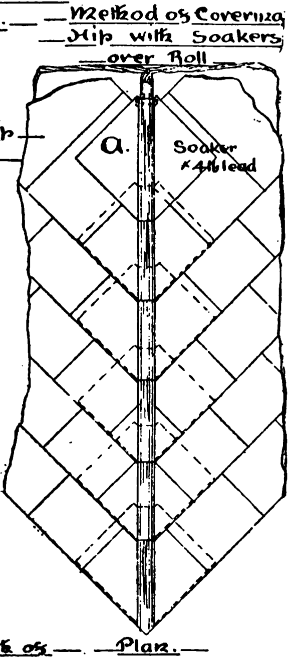


Fig. 442. Fig. 443.

Difference between Valleys and Hips.—If the upper surfaces of the slopes of adjacent roofs include an angle less than 180°, or, in other words, form a hollow, it is termed a valley; but if the angle be greater than 180°, thus becoming a ridge or projection, it is called a hip.

Hips.—May be made effectually watertight in one of two ways. First, by dressing a piece of lead of the required width and not longer than 7 feet over a roll and letting it project 6 inches down the slope on either side of roll in a similar manner to a ridge, provision being made to prevent the lead sliding down the slope, which is accomplished as follows:—The lowest piece of hip roll is fixed; the first piece of lead is laid on, extending 6 inches past and being bossed over each end of roll, as shown in figure 442; the next length of roll is placed in position and fixed, its lowest extremity resting on the upper end of the first piece of lead, thus securely fastening and preventing any sliding. The second piece of lead is then proceeded with, lapping over the first piece 12 inches. Each length of lead should be supported at its centre by a lead tack, and the lower piece should be clipped over the upper at each lap joint. Secondly, the hip may be formed by soakers, which may either be fixed over a roll, as shown in figure 443, where they are visible, or the roll may be dispensed with, in which case there is a saving of lead.

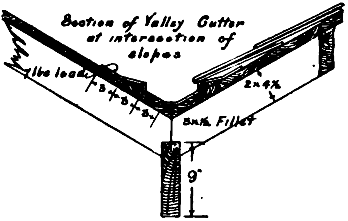


Fig. 445.

Figure 444 shows a plan of a hip soaker.

Valley Coverings.—In valleys, the coverings may be arranged to form a small gutter, small fillets being fixed on slopes of roofs to tilt the slates, as shown in section figure 445.

Stepped Flashings.—The joints between sloping roof surfaces and end walls are best protected by means of pieces of sheet lead, called step flashings, resting about

6 inches on roof and 6 inches against wall; the upper edges are turned 1½ inches into the raglets or joints of brickwork prepared to receive them. and are fixed as described in the paragraph on flashings. Figure 451 refers to this kind of flashing. To set out step flashings, first roll out the piece of lead, which should be 13 inches wide, then fold it lengthways in the centre, like the letter L. Draw a line, 2½ inches distant from the angle, on the stand-up side. This line is usually called the "water-line." The piece of lead should then be laid in its position on the roof, and the horizontal joints in the brickwork transferred to the lead between the top edge and the water-line. Next draw lines from the points where the horizontal lines cut the water-line, to the point where the horizontal line immediately above cuts the outer edge of the piece of lead. Draw other lines 1½ inch distant, parallel with and above the horizontal lines. The small triangular pieces of lead above these last lines to be cut out with a knife. The pieces between the parallel lines to be folded and wedged into the raglets of the brickwork.

Raking Flashing.—Is the name given when the turned-up edge of a flashing is secured to a chase or raglet, cut parallel to slope of roof. This method is adopted for stone walls adjoining sloping roofs.

Flashings for Chimney Stacks.—Figures 446-453 show the mode of preventing any leakage through the joints on the four sides of a chimney stack; at the upper end by means of a gutter; at the sides by fixing stepped flashing or secret gutters; and at lower end with an apron piece and using lead wedges and tacks, as shown in figures 446 to 450.

Secret Gutters.—Sometimes flashings are arranged to form secret gutters instead of laying the lead on the slates.

DETAILS OF FLASHINGS FOR CHIMNEYS.

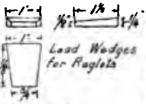


Fig. 446.

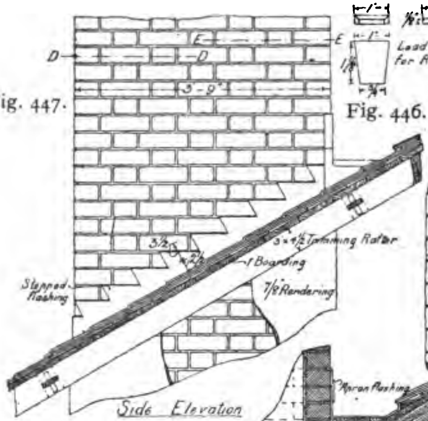


Fig. 447.

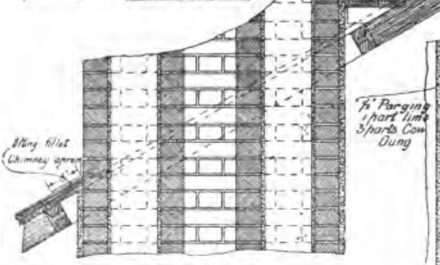


Fig. 448.

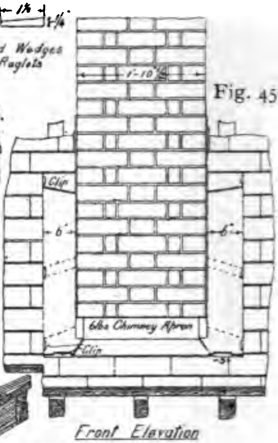


Fig. 450.

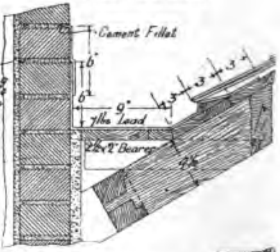
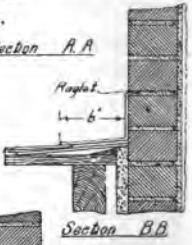


Fig. 451.

Enlarged Section A.A



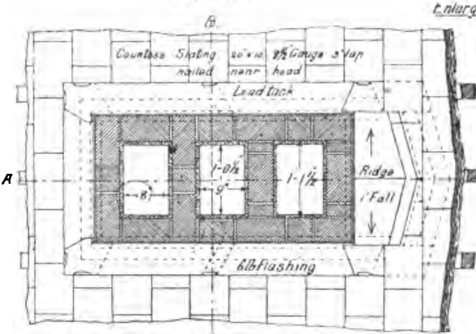


Fig 449.

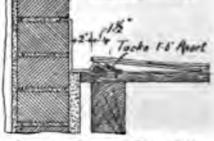


Fig. 453.

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These secret gutters derive their name by reason of the slates hiding them from view. In some situations the slates are carried over the secret gutter so as to nearly touch the wall, thus protecting the lead from the sun; but the arrangement is bad in any position where leaves of trees or any rubbish might drift and choke the gutter. To obviate this, the gutter is better constructed, as shown in figure 453, where the tilting piece forms the depth of the trough, and the edge of the lead under the slates is bent to form a small welt to guide any water away that might pass over the fillet.

Figure 454 shows the boarding cut short on the rafters to give depth to the gutter, and a hollow welt is turned on the edge of the lead for the purpose given above.

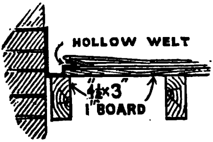


Fig. 454.

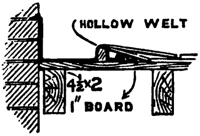
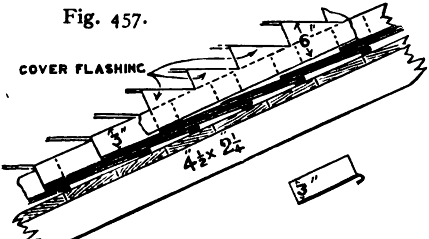


Fig. 455.

Side Gutters.—Water is often conveyed from the upper portions of mansard roofs by side gutters, as shown in figure 455, and is a better arrangement than using the ordinary flashing, as in the latter method the water in falling over has a tendency when driven by the wind to splash about and get under the flashings, especially where the intersecting slopes of roof and ridge is an acute angle.

Soakers.—The intersections of sloping roof surfaces with end gables or penetrating walls are made weathertight by means of pieces of lead termed soakers, fixed parallel to wall, and resting on slopes about 4 inches, and being turned up against wall from 2 to 3 inches, a cover stepped or raking flashing is fixed over the turned up edges. The soakers should be the length of the slates minus the margin and plus an inch for clipping over the heads of slates. Figure 456 shows a soaker cut for Countess slates; and figure 457 is an elevation of soakers, fixed with a stepped cover flashing over them to prevent the water leaking between the soakers and the wall. This is better than ordinary stepped flashings, as the wind cannot blow the rain between the roof and wall in the same manner as when ordinary stepped flashings are used.

Fig. 457.



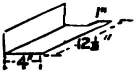


Fig. 456.

In some cases each soaker is allowed a length of 6 inches to turn up against the wall, and steps are cut and the edges tucked into raglet, as in ordinary stepped flashing. This is a good plan, but takes a longer time to execute.

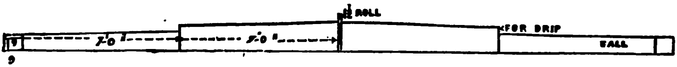


Fig. 458.

Gutters.—Rain water that falls upon roofs naturally runs to the lowest part, and provision must be made to carry the water away. This is generally done by means of gutters.

Gutters may be eaves or parapet gutters.

Eaves gutters usually consist of a small iron trough, as illustrated in figure 278. In a storm or great downpour of rain they do not, as a rule, accomplish the purpose for which they are intended, and it is not advisable to fix them on any side of a roof that overhangs the public highway. They are usually of cast iron, but should be fixed under the direction of the plumber.

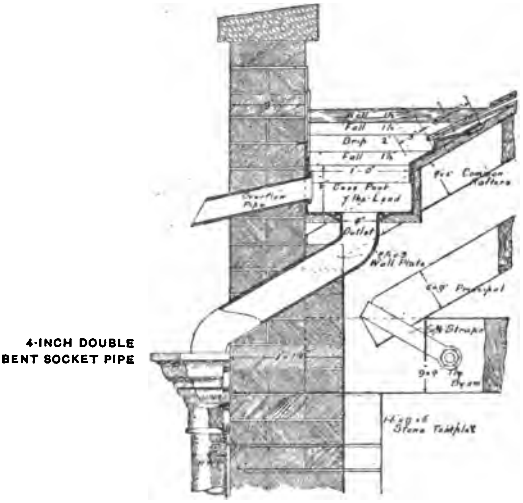


Fig. 459.

If a roof slopes toward the public highway, it is recommended to construct a parapet gutter as a guard against slates, tiles or snow falling into the street.

Parapet Gutters.—Gutters on the outer side of which a parapet wall is constructed are named parapet gutters, and may be parallel or tapering.

Tapering Parapet Gutters. — Parapet gutters are of irregular width where their plans are as shown in figure 458. This suits the construction of roofs where the common rafters rest on wall plates. Figure 459 shows how to obtain the required widths of sheet lead at the different positions in the gutters.

Parallel Parapet Gutters.—Roofs constructed with the common rafters resting on a pole plate fixed some distance away from the parapet, are termed parallel gutters, as shown in figure 460. The pole plate must be sufficiently deep to allow for all necessary falls and drips, which are required equally as much in this method as when the ordinary tapering shaped gutters are used. The timbering for this construction is more expensive than in the ordinary shaped gutters.

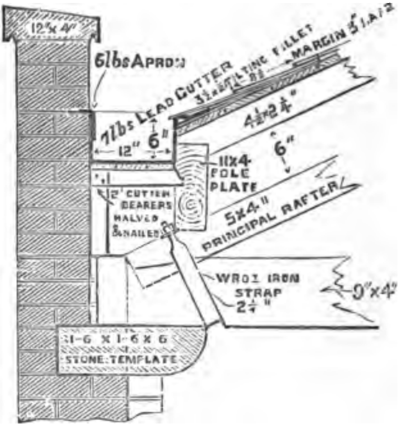


Fig. 460.

Tapering Valley Gutters.—Gutters constructed between the slopes of two adjacent roofs, are called valley gutters, and may be taper shaped when the construction of roof is that of common rafters of adjoining slopes resting on the same plate. Figure 461 shows a section giving all necessary details for such gutter.

A similar section to this is often applied for sloping valleys, in which position no drips are required.

Parallel Valley or Box Gutters.—When a roof is constructed so that the common rafters of adjacent slopes are

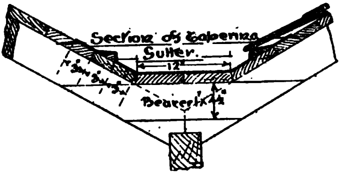


Fig. 461.

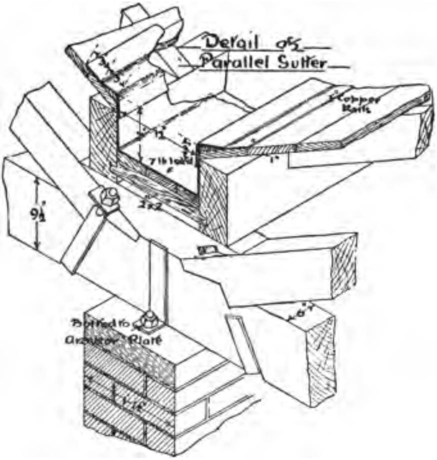


Fig. 462.

fixed to separate pole plates, parallel gutters may be made. If the depth of the gutter is more than 12 inches at the deepest end, it is usual to fix a lead apron, as shown in figure 462, instead of turning the gutters under slates, as in figure 460.

Gutters are constructed in M shaped roofs where it is necessary to convey the water from the valley to one of the side gutters by forming timber troughs lined with lead connecting the gutters mentioned; they are then more particularly known as box gutters.

Snow Boards.—These are provided in all important gutters to preserve an uninterrupted channel to drain the water from the melting snow after a heavy snowstorm when the whole roof is covered. Under these circumstances the snow thaws on the underside first, through being in contact with the warm roof; but if the gutters and outlets be choked with frozen snow, that which is thawed will gain access through the joints in the roofing material. The snow boards consist of a number of strips of 2 inches × 1 inch placed in the gutter with their length parallel to the current of the gutter and spaced about $\frac{3}{4}$ inch apart, they are supported by and fixed to cross-pieces 4 inches × 2 inches. From the underside of these bearers a piece at least 2 inches wide is taken out from the centre and extends to within 3 inches from each end, forming an arch for the melted snow to flow through. These are especially necessary on all valley roofs.

Snow Guards.—These consist of a low iron railing that should be fixed at the lower edge of all eaves roofs, to prevent large masses of snow slipping down the roof surface and falling over the eaves; they should be at least one foot high, and the rails should be large enough to thoroughly break the masses. In severe climates on eaves roofs these should never be omitted.

Burning In.—Lead cover flashings for parapet gutters are sometimes secured to the stone blocking course by being turned into a groove, or raglet, cut dovetail shape, on the top or front surface of the stone; molten lead is then poured into the groove which thoroughly secures the flashing to the stonework, as shown in figure 463. In some cases it is necessary to "set up," that is, to hammer in close with caulking tools which are similar to blunt chisels with a rounded end, and fill the groove, to ensure it being thoroughly secured, as the molten lead shrinks on cooling.

Soldered Dots.—Where large vertical surfaces have to be covered with lead, as on dormer cheeks, they are sometimes secured in the following manner:—Round hollowings, 3 inches diameter, are made in the boards; the lead is dressed well into these hollowings and screwed to the boards and studs (which latter are better for screwing to if against the required position). A tinned copper washer should be placed under the head of the screw to distribute the fixing over a greater surface of lead, so that when shrinkage or expansion takes place, the lead shall not be torn by the screw. The hollow is encompassed by a ring of soil (which is a composition of size, lamp black and chalk) to prevent the solder from adhering to the flush surface of lead covering. The hollow is then filled up level by means of solder, and is then known as a soldered dot, as shown in figure 464. Lead fixed in this manner is liable to cracks occurring near the soldered dots.

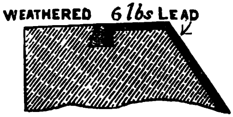


Fig. 463.

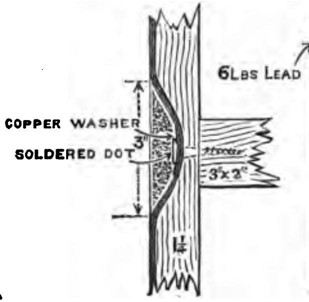


Fig. 464.

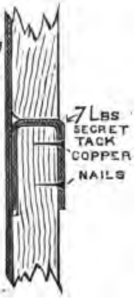


Fig. 465.

Secret Tacks.—A better mode of fixing dormer cheeks is shown in figure 465, where a lead tack is soldered to the back side of the lead covering. The loose end of the tack is passed through a slot cut in the boarding, and secured by copper nails on the inside. The tack, or secret tack as it is called, fixes the covering securely, and is not so unsightly as is the former method.

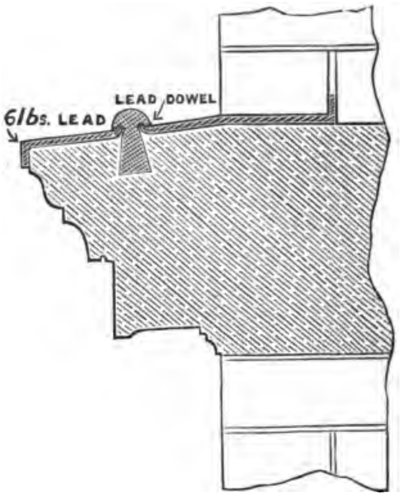
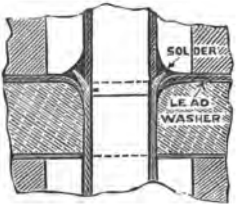


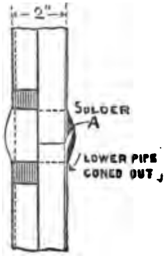
Fig. 466.

Lead Dowel or Dot.—Where exposed parts of stone cornices, strings, etc., that are covered with sheet lead require to be protected from high winds, lead is laid before the wall or blocking course is built, it may be turned up and built in the mortar joint, as shown in figure 466, or the lead may be passed through the wall, and turned down on the inner side. If laid after the wall is built, the lead may be dressed against the face of wall and tucked and wedged in a mortar joint that has been raked out to receive it. To prevent the free edge of flashing being torn up by wind, circular holes are made in the lead and surface of stone exactly opposite each other, the edges of lead round the hole being turned up slightly. An iron mould with a small hole through the top is pressed over the hole in the lead and stone, and molten lead poured through the mould, filling up the holes prepared to receive it, and also filling up the cup shape hollow of mould. This fixing is called a lead dowel or dot.

Fig. 468.

SECTION





HALF ELEVATION HALF SECTION

Fig. 467.

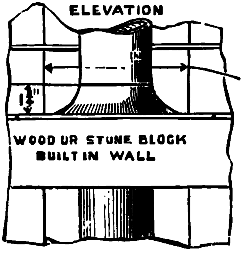


Fig. 469.

Wiped Joint.—The joints of all lead pipes which convey water under pressure should be wiped, as shown in figure 467. The process of making the joint is as follows:—The end of one piece of pipe is opened, as shown in figure 467, by means of a tan pin (a conical shaped piece of wood). The end of the remaining piece of pipe is filed to present a sharp edge on the internal

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face. The pipes are then fitted, care being taken to keep the internal surfaces true. The two ends are covered with soil for about 3 inches from the extremities. The pipes, for about 1½ inches from each end, are scraped bright with a tool called a shave hook. The pipes are placed together and secured in position; the molten solder is then poured on from a ladle and wiped round the joint with a piece of greased cloth. The solder adheres to the part that has been shaved and forms a sharp line about the pipe at its junction with the soil. The covered end marked A should always be in the direction of the current. Plumbers' solder is composed of two parts, by weight, of lead to one of tin.

Blown Joint.—This is an inferior kind of joint, used for connecting lead pipes together. The ends are prepared and fitted as for the wiped joint and secured in position; a little flux, usually resin, is applied to the joint to aid in the fusion of the lead and the solder. The stick solder is used, and is melted by means of a blow-pipe flame, the solder only filling up the part of the pipe that has been opened out. It is the usual joint employed in composition pipes for gas, these being much lighter in section, and the maximum pressure on such joints being small.

Block Joint.—Where large pipes are fixed in vertical chases of walls, that are prepared to receive them, the following soldered joint is sometimes constructed, and may be made as follows:—The top end of the lower length of pipe is passed through a circular hole, cut in a wood or stone block built in the wall, and the end of the pipe turned over a lead collar, which is placed upon the block. The upper length of pipe, with the ends prepared, is then arranged in its proper position over the lower one, and the joint soldered, as shown in figures 468 and 469.

CHAPTER XIII.

SLATING.

Slates are used to cover roofs. They are considerably lighter than tiles and are not so absorbent, consequently the scantlings for a slated roof need not be so large as those for a tiled roof. They may be obtained in the market, of various dimensions as given ;—

Dimensions of Slates.

	Inches.
Smalls	12 × 6
Doubles	13 × 7
Ladies (large)	16 × 8
Countesses	20 × 10
Duchesses	24 × 12
Princesses	24 × 14
Empresses	26 × 16
Imperials	30 × 24
Rags	36 × 24
Queens	36 × 24

But the sizes in common practice are as follows :— Duchess slates, 24 inches by 12 inches, for moderate flat roofs of $\frac{1}{5}$ pitch ; Countess slates, 20 inches by 10 inches, for roofs of $\frac{1}{4}$ pitch ; and Ladies, 16 inches by 8 inches, for roofs of $\frac{1}{3}$ pitch—the practice being the steeper the pitch the smaller the slate, and the more exposed the building the greater the pitch of the roof.

The following terms are used in slaters' work :—

Head	..	The upper or top edge of slate.
Back	..	The upper or exposed surface of slate when laid.
Bed	..	The lower or under surface of a slate.
Tail	..	The lower or bottom end of slate.
Margin	..	The part of each course of slates exposed to view.
Gauge	..	The distance apart nails have to be inserted on battens or boards; this is required to determine the position of the battens to receive the nails by which the slates are secured.
Bond	..	When a joint of two adjacent slates is immediately in the centre of the slate, the tail end of which rests upon them, the slates are said to bond.
Lap	..	The distance the tail of one slate overlaps the head of second course below, when slates are nailed near the centre, or the distance the tail of slate overlaps the nail hole of second course below when slates are nailed near the head. The lap in practice ranges from 2½ inches to 4 inches; in this book it will be taken as 3 inches.
Holing	..	The piercing of slates to receive nails.
Sorting	..	Where the roof is be covered by slates of different lengths, they are regulated to proper dimensions so that the largest slates may be nailed near the eaves, and the smallest at the ridge.
Eaves	..	The lower part of slating hanging over a wall.

There are three methods of laying slates :—

1st.—By nailing near the head.
2nd.—By nailing near the middle.
3rd.—By fixing with copper wire.

The groundwork to receive slates may be prepared in one of the following methods :—

1. *With Wood Battens* nailed horizontally across rafters fixed to the required gauge.

2. *With Close Boarding*—that is, the rafters are boarded over, and the slates nailed direct to the boards: this is a better method than battening.

3. *With Close Boarding and Asphalted Felt.*—The felt is a non-conductor and prevents radiation, and thus preserves a more equable temperature in the interior of buildings; it is also waterproof, and thus forms an extra precaution against damp.

4. *Close Boarding Felt and Battens.*—Where the slates are laid direct on the felt the latter is liable to decay, from want of ventilation; to prevent this, battens are laid horizontally on the felt to which the slates are fixed, thus allowing a circulation of air over the surface of the felt.

5. *Close Boarding, Felt, Vertical and Horizontal Battens.*—The last method is open to the objection that should any water find its way between the slates, as in the case of a broken slate, the water would lodge upon the horizontal battens and cause them to rot. To avoid this, battens are first laid on the felt to the slope of the roof, and fixed one over each rafter; horizontal battens are nailed to these again, and then the slates, so that should any water get beneath the slates it can run away: this leaves a larger air space, which is better for ventilating the battens and felt, also for preserving the temperature inside the building. This method should be adopted on all monumental buildings, and on roofs not easily accessible.

Gauge for Nailing Slates near the Head.—In this method of fixing slates, the nail holes are placed one inch from the head. The calculations to ascertain the gauge are as follows:—One inch plus the lap is deducted from the total length of slate, the first being due to the material above the nail hole, not being included in the lap, and the remainder is divided by two, which will give the gauge, and may be stated thus:—

$$\text{Gauge} = \frac{\text{length of slate} - 1'' - \text{lap}}{2}, \text{ which}$$

In Duchess Slates would be $\frac{24 - 1 - 3}{2} = \frac{20}{2} = 10$ inches.

,, Countess ,, ,, $\frac{20 - 1 - 3}{2} = \frac{16}{2} = 8$,,

,, Ladies ,, ,, $\frac{16 - 1 - 3}{2} = \frac{12}{2} = 6$,,

Figures 277 and 470 show slates fixed by this method.

Gauge for Fixing Slates near the Middle.—The gauge is determined as follows :—The lap is deducted from the length, and the remainder is divided by 2, and may be stated thus :—

$$\frac{\text{Length of slate} - \text{lap}}{2}$$

In Duchesses would be $\frac{24 - 3}{2} = 10\frac{1}{2}''$.

„ Countesses „ $\frac{20 - 3}{2} = 8\frac{1}{2}''$.

„ Ladies „ $\frac{16 - 3}{2} = 6\frac{1}{2}''$.

Figures 278 and 471 show slates fixed by this method.

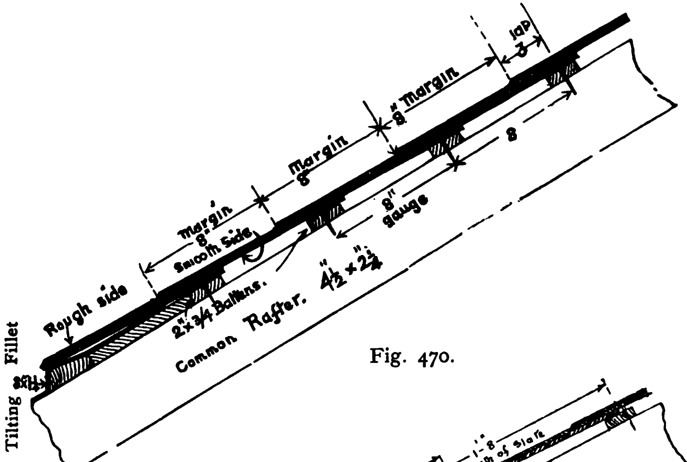

Fig. 470.

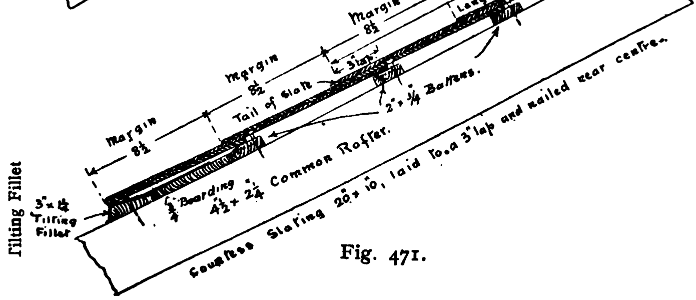

Fig. 471.

The slater determines the position of nail hole in following manner: the lap is added to the gauge, and ½ inch for clearance is allowed—measurements being taken from the tail. It may be stated thus :—

Gauge + lap + ½″ = distance of nail hole from tail—

In Duchesses would be 10½ + 3 + ½ = 14″.
,, Countesses ,, 8½ + 3 + ½ = 12″.
,, Ladies ,, 6½ + 3 + ½ = 10″.

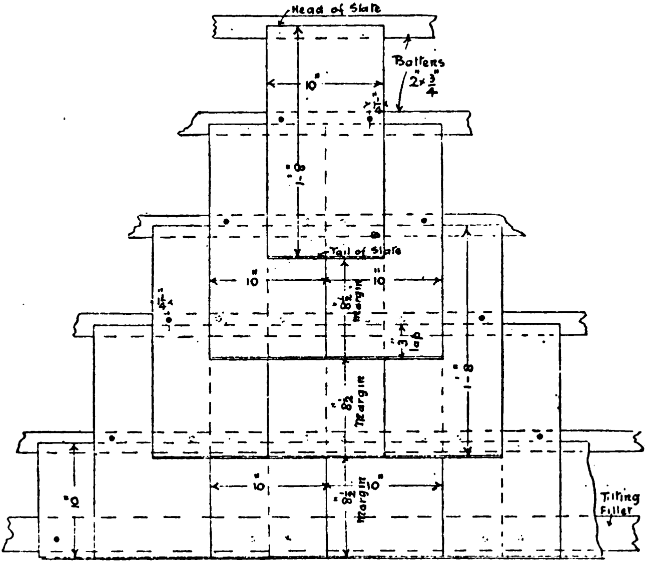

Fig. 472.

The distance of nail holes from the long edges in either method is 1¼ inches.

It can thus be observed that less slates will be required to cover equal areas of similar roofs by the method of nailing near the middle, than by the method of nailing near the head.

Advantages and Disadvantages.—Of the two methods—are as follows:—Slates that are nailed near the head always have two thicknesses of slate over every nail hole, and the lap is practically 1 inch more than that which is calculated if we take into account that portion above nail holes; but as this method requires more slates, it is therefore more expensive; and the long distance the nails are fixed from tail allows the wind to act with a greater leverage, which, in bad weather, sometimes strips the roof.

Open Slating.—Slates are sometimes laid so that the adjoining slates of the same course are a distance apart, about 2 inches, as in figure 473. A roof covered in this manner would not require nearly so many slates as the former methods; it is largely used for sheds or temporary buildings.

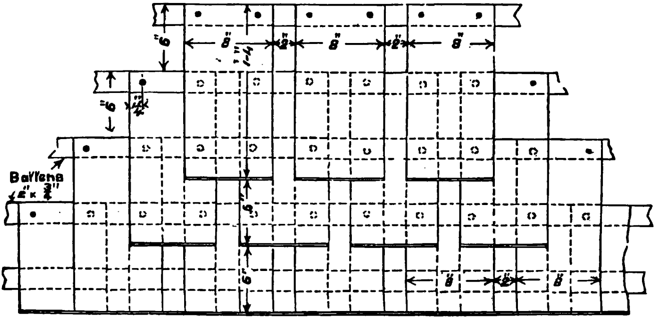

Fig. 473.

Doubling Eaves Course.—Slates are laid commencing at the eaves; the length of the slates should be as follows:—Gauge + lap + 1 inch in slates nailed near the head. In Countess slates this would be 8 + 3 + 1 = 12 inches, and nail hole would be 11 inches from tail, as shown in figure 470. Where slates are nailed near the centre, gauge + lap is the length; this would be in Countess slates $8\frac{1}{2} + 3 = 11\frac{1}{2}$ inches, and the nail hole would be over the centre of tilting piece, as shown in figure 471; but if the tilting piece is covered with lead, the nail holes would be made near the head.

Smooth Side of Slates.—Slates have one side smoother than the other, and a slater, in cutting on the smooth side, obtains a sharp edge, but on the rough side it is jagged. The doubling eaves course is laid with its smooth side up, the course above and all succeeding courses are laid with their smooth side down, so as to obtain a close joint to guide away the rain and wind, as in section figure 470.

Lead and Copper Tacks.—These are used for repairing defective slated roofs, the method being as follows:—The broken slates are removed, the nails being cut or drawn by a tool called a ripper, which has a thin blade about 2 feet long and 1 inch wide, being about 2 inches broad at the end, with a notch each side to receive nail; the tack is then hooked over the head of the slate below, the new slate is inserted, and the lead clip turned up over the tail. Two tacks should be used to each slate.

Tilting Fillets.—To enable the tails of slates to fit closely against the slate below, and to form a close joint to keep out wind and wet, a tilting fillet or springing piece, as it is sometimes called, must be nailed under tail of first slate or doubling course. This will give all the slates a tilt, and cause them to bend on their tails. The slates will consequently be slightly apart, the less distance apart the better, so that, during repairs, they may be less likely to be broken. The tilting pieces are about $\frac{1}{2}$ to $\frac{3}{4}$ inch thick, and tapered, as in section figure 277.

When roofs are battened, instead of a separate tilting piece, the first batten may be 1¼ to 1½ inches thick, and tapered, as shown in section figure 471.

Tilting fillets are also used against chimney breasts, to guide water away from walls, as in section figure 452, or at ridge, to compensate for the tilt of slate lost by its length being shorter than others, as in section figure 474, or in any position where slates are desired to be slightly raised.

Tails of Slates.—Slates should be laid with their tails horizontal, but wherever taper shaped gutters occur in roofs the side of the gutter nearest the ridge is not parallel with it, as shown in plan, figure 458. So the tails of doubling courses form an exception to this rule.

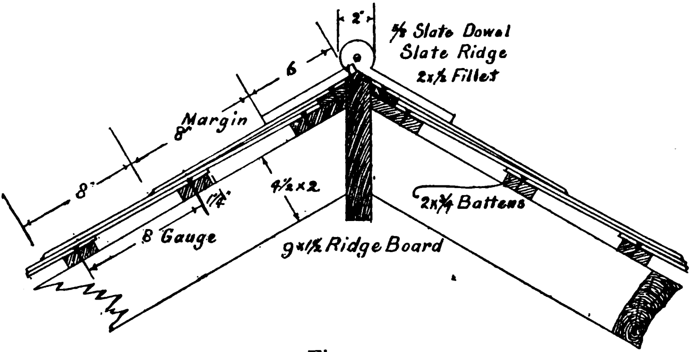

Fig. 474.

Slate Hips and Ridges—Are now much used in the place of lead to save expense, these are dowelled together with small slate dowels and bedded in hair mortar. Figure 474 shows section of one method in use.

Nails.—Slating nails have flat circular heads, have a sharp point on shank and are made from 1¼ to 2 inches long. There are four kinds in general use, viz., iron, zinc, copper and composition :—

(1). *Iron* nails may be either cast or malleable. The cast resist oxidation better than the malleable, but being brittle are inferior to the above, and are only used for cheap work. Malleable nails are first cast and then made malleable ; they are often galvanized or painted to resist oxidation, but they are better when dipped while hot into boiled linseed oil, which method is frequently and successfully adopted.

(2). *Zinc.*—Zinc nails are very soft and easily broken ; they are not well adapted for driving, and are therefore wasteful and expensive to use.

(3). *Copper Nails.*—These may be obtained as wrought or cast, are very soft, expensive, and are not much used.

(4). *Composition.*—These are a mixture of zinc, copper and tin. The alloy is much harder than either the copper or the zinc, does not oxidise to any extent and is better adapted for driving ; these should be employed on all important work.

EXERCISES.

BRICKWORK.

No.	Page	Question	No.	Page.	Question.	No.	Page.	Question.
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2	229	1	11	235	5	20	231	10
3	229	5	12	241	5	21	255	8
4	232	1	13	244	6	22	258	12
5	235	1	14	247	6	23	259	6
6	238	1	15	234	9	24	261	12
7	241	1	16	238	7	25	262	2
8	244	1	17	241	8	26	264	8
9	247	2	18	243	9		..	..

MASONRY.

1	226	2	9	247	4	17	231	8
2	229	2	10	250	4	18	234	10
3	232	2	11	250	5	19	249	12
4	235	2	12	232	6	20	253	2
5	238	2	13	235	6	21	253	5
6	241	2	14	238	5	22	256	5
7	244	2	15	226	6	23	259	4
8	247	1	16	246	9	24	262	5

GIRDERS.

1	226	4	5	238	4	9	250	6
2	229	3	6	241	3	10	243	14
3	232	4	7	241	6	11	255	9
4	235	4	8	247	7	12	264	12

JOINTS IN CARPENTRY.

1	226	3	5	250	2	9	228	9
2	232	3	6	244	5	10	241	4
3	235	3	7	237	13	11	253	3
4	247	5	8	241	7	12	255	14

FLOORS.

1	226	5	8	246	10	15	249	13
2	229	4	9	252	9	16	234	13
3	244	3	10	228	10	17	259	7
4	247	3	11	231	11	18	258	10
5	229	7	12	243	10	19	261	10
6	237	8	13	246	12	20	262	1
7	240	8	14	237	12	21	262	6

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PARTITIONS.

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WOOD ROOFS.

1	228	3	7	232	7	13	237	13
2	241	4	8	237	11	14	253	7
3	232	5	9	247	8	15	258	9
4	238	6	10	249	11	16	261	8
5	226	7	11	252	11	17	264	9
6	229	6	12	243	12			

COMPOSITE ROOFS.

1	240	12	2	262	4	..	..	..

IRON ROOFS.

1	244	7	4	234	14	7	258	14
2	252	10	5	240	14	8	264	13
3	228	13	6	261	13	..		..

JOINERY.

1	250	3	8	234	12	15	240	13
2	235	7	9	246	13	16	243	13
3	240	9	10	246	14	17	228	14
4	250	8	11	249	14	18	261	14
5	231	9	12	252	14	19	258	11
6	243	11	13	231	13	20	255	10
7	228	12	14	237	13	21	264	14

PLUMBING.

1	244	4	4	237	10	7	264	10
2	250	7	5	252	12	..	..	..
3	249	9	6	255	13	..	..	..

SLATING.

1	234	8	3	249	10	5	240	10
2	244	8	4	228	8	6	231	14

APPENDIX.

SCIENCE & ART SYLLABUS.

SUBJECT III.

BUILDING CONSTRUCTION.

As the object of this Course of Instruction is to lay the foundation of a sound knowledge of the principles, as well as of the practice, of Building Construction, and so lead the workman to labour with his head at the same time as with his hands, the teacher should not, necessarily, attempt to push the students through the whole of the subjects enumerated in this syllabus, but should limit the range of his tuition according to the time at his command and the intelligence of the pupils.

A larger number of questions will be set in the examination papers for the Elementary and Advanced Stages than the candidate will be allowed to attempt, so that he will, to a certain extent, be able to show his knowledge in such branches as he may, from circumstances, have paid special attention to. For instance, a student better acquainted with iron than wooden structures will be able to select a question on iron work, in preference to one on wood work. In order, however, to ensure that special attention shall not be given to work of one description only, a certain number of the questions given will be compulsory, *i.e.*, the candidate must attempt these, and unless he shows a sound knowledge of work of more than one kind, by answering a fair proportion of them, the rest of his paper will not be considered.

Moderately good drawing, showing an intelligent knowledge of the subject, will always be awarded higher credits at the examination than more highly finished drawings exhibiting an ignorance of constructive details.

First Stage, or Elementary Course.

It is assumed that the student has already mastered the use of the following drawing instruments: rulers, ordinary and parallel; ruling pen; compasses, with pen and pencil bow-sweeps, as well as the construction and use of the simple scales, such as 1, 2, 3, or more feet to the inch, showing inches; or such as ½, ⅓, ¼, ⅔, ⅗, ⅝, or other fraction of full size, or of any given scale or drawing: also the meaning of such terms as plan, elevation (front, back, or side), section, sectional elevation.

He should understand the object of bond in brickwork, *i.e.*, English bond, Flemish bond, or English bond with Flemish facing, and how it is attained in walls up to three bricks thick in the following instances, viz., footings with offsets, angles of buildings, connexion of external and internal walls, window and door openings with reveals and square jambs, external gauged arches (camber, segmental, and semi-circular), internal discharging arches over lintels, and inverted arches.

He should know where to put wood bricks, or plugging, and their use : the construction and uses of brick corbeling, and the construction of trimmer arches in fire-places.

He should be able to give sections and elevations to scale of the following kinds of mason's work, viz., uncoursed and coursed rubble, block in course, and ashlar, with their bond, and the proper dimensions of the stones, as to height, width of bed, and length; and of the following dressings, viz., window sills, window and door jambs, plain window and door heads, door steps, string courses, quoins, copings, common cornices, blocking courses; and of the following methods of connecting stones, viz., by cramps, dowels, joggels, and lead plugs.

He should be able to show how to join timbers by halving, lapping, notching, cogging, scarfing, fishing, and mortise and tenon; as applied to wall plates, roof timbers, floors, ceilings, and partitions.

He should be able to draw, from given dimensions, couple, collar, and king-post roofs, showing the details of the framing and of the ironwork.

He should be able to draw, from given dimensions, single, double, and framed floors, with or without ceilings beneath them; showing modes of supporting, stiffening, and framing the timbers, trimming round hearths and wells of stairs; also floor coverings of boards or battens, rebated and filleted, ploughed and tongued, and laid folding, with straight or broken joints, bevelled or square heading joints.

He should be able to draw in elevation, from given dimensions, a framed partition with door openings.

He should be able to draw in elevation, and give vertical and horizontal sections of solid door frames and window frames.

He should be able to describe, by drawings, beadings of different kinds, dovetailing, cross-grooving, rebating, plough-grooving, chamfering, rounded nosing, and housing.

He should be able to draw in elevation, and give vertical and horizontal sections of, the following doors, viz., ledged, ledged and braced, framed and braced, panelled, and the mode of putting them together, position of hinges and furniture; as well as to describe, by drawing, the following terms as applied to panelled doors, viz., square and flat, bead butt, bead flush, moulded, all on one or both sides.

He should be able to draw in elevation, and to give vertical and horizontal sections of the following window sashes and frames, viz., single or double hung sashes with square, bevelled, or moulded bars, and cased frames; casement sashes hung to solid frames, with method of hanging and securing in each case.

He should be able to draw, in elevation and section, the leadwork connected with chimneys, ridges, hips, valleys, gutters, and lead-flats.

He should be able to give an elevation and section of the slating of a roof laid with Duchess or Countess slates on boards or battens.

He should be acquainted with the proper cross section for cast-iron beams for use in floor girders or bressummers, or as cantilevers; and be able to draw such a section in its right proportions from given dimensions of flanges.

He should be able to draw in elevation, from given dimensions and skeleton diagrams, ordinary iron roofs up to 40 feet span, showing the sections of different parts, and methods of connecting them.

SECOND STAGE, OR ADVANCED COURSE.

In addition to the subjects enumerated for the Elementary Course—in all of which questions of a more complicated nature may be set, combining work done by the different trades—the knowledge of the students will be tested under the following heads, viz:—

1st. Freehand sketches explanatory of any details of construction, such as the joints of iron and wooden structures, and other parts requiring illustration on an enlarged scale. These sketches may be roughly drawn, provided they are clear and capable of being readily understood.

2nd. The nature of the stresses to which the different parts of simple structures are subjected, as follows :—

In the case of beams either fixed at one or both ends, or supported or continuous, the student should know which parts of the beam are in compression, and which in tension.

He should be acquainted with the best forms for struts, ties, and beams, such as floor joists, exposed to transverse stress.

He should know the difference in the strength of a girder carrying a given load at its centre, or uniformly distributed.

In the ordinary kinds of wooden or iron roof trusses, and framed structures of a similar description, he should be able to distinguish members in compression from those in tension.

He should be able, in the case of a concentrated or uniform load or any part of a beam supported at both ends, to ascertain the proportion of the load transmitted to each point of support.

3rd. The nature, application, and characteristic peculiarities of the following materials in ordinary use for building purposes, viz. :—

Bricks of different kinds in common use, York, Portland Caen, and Bath stones (or stones of a similar description), granite, pure lime, hydraulic lime, Portland and Roman cement mortars, concretes, grout, asphalte, timber of different kinds in common use, cast and wrought iron, lead.

4th. Constructive details, as follows :—

The ordinary methods of timbering excavations, such as for foundations to walls, or for laying down sewers; the erection of bricklayer's and mason's scaffolding; the construction of travellers; the use of piles in foundations, hoop-iron bond in brickwork, diagonal and herring-bone courses in ditto, damp-proof courses, bond timber in walls and the objections to it.

He should know how bricks are laid in hollow walls, window or door openings with splayed jambs, flues, chimneys, fireplaces, and arches up to about 20 feet span; how mortar joints are finished off, and the thickness usually allowed to them; why bricks and stones ought to be wetted before being laid.

He should be acquainted with the construction of brick ashlar walls, rubble ashlar walls, stone stairs, wooden stairs (both dog-legged and open newel), skylights, fire-proof floors (such as brick arches supported on rolled or cast-iron girders, Fox and Barrett's, and Dennett's patent concrete floors), circular and egg-shaped drains, roofs of iron or wood, for spans up to 60 feet; the fixing of architraves, linings and skirtings to walls, shutters to windows, lath, plaster, and battening to walls, roof coverings of tiles and zinc, slate ridges and hips.

Written answers will be required to some of the questions.

EXAMINATION FOR HONOURS.

The candidate will have to furnish a design for a building, or part of a building, in accordance with given conditions; which design he will be allowed to draw out at his own home.

He will be called upon to answer in writing—illustrated by sketches, either freehand or to scale, as directed—questions on all the subjects previously enumerated for the elementary and advanced courses.

He must possess a more complete knowledge of building materials, their application, strength, and how to judge of their quality; and in the case of iron, of the process of manufacture, and the points to be attended to in order to insure sound castings, and good rivetting.

He must be able to solve simple problems in the theory of construction, and to determine the safe dimensions of iron or wooden beams subjected to dead loads.

In ordinary roof trusses, and framed structures of a similar description, he must be able to trace the stresses, brought into action by the loads, from the points of application to the points of support, as well as to determine the nature and amount of the stresses on the different members of the truss, and, consequently, the quantity of material required in each part.

In ordinary walls and retaining walls, he must be able to ascertain the conditions necessary to stability, neglecting the strength of the mortar.

EXAMINATION PAPERS

OF THE

SCIENCE & ART DEPARTMENT, SOUTH KENSINGTON.

SUBJECT III.—BUILDING CONSTRUCTION.

EXAMINER, COLONEL SEDDON, R.E. (Ret.)

GENERAL INSTRUCTIONS.

IF THE RULES ARE NOT ATTENDED TO, THE PAPER WILL BE CANCELLED.

You may take the Elementary, or the Advanced, or the Honours paper, but you must confine yourself to one of them.

Your name is not given to the Examiner, and you are forbidden to write to him about your answers.

All figures must be drawn on the single sheet of paper supplied, for no second sheet will be allowed.

All drawings must show a correct knowledge of construction. Neat and accurate drawing to scale is required. Where only sketches are asked for, the proportions must be approximately correct, though extreme accuracy, as in drawings to scale, is not necessary. The drawings may be left in pencil, provided they are distinct and neat. No extra marks will be allowed for inking in.

You are to confine your answers *strictly* to the questions proposed.

Put the number of the question before your answer.

Answers in writing must be as short and clearly stated as possible, and close to any figures to which they may refer.

The value attached to each question is shown in brackets after the question. But a full and correct answer to an easy question will in all cases secure a larger number of marks than an incomplete or inexact answer to a more difficult one.

A single accent (′) signifies *feet*; a double accent (″) *inches*.

Questions marked (*) have accompanying diagrams.

The examination in this subject lasts for four hours.

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA.

MAY, 1881.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

---

*1. Elevation and section of part of a dwarf brick wall.

Draw the elevation to twice the scale, showing 4 courses of English bond at A, and 4 courses of Flemish bond at B. (11.)

*2. Vertical section of joint between two stones.

Draw, to a scale of 1½" to a foot, showing a metal cramp run with lead. (11.)

*3. Plan of timbers crossing one another.

Draw, to a scale of ⅛, two sections through *a a*; the first to be marked A, showing a notched joint; and the second to be marked B, showing a cogged joint. (11.)

4. One of the flanges of a cast iron *cantilever* is 5" × 1½", and the other 2" × 1"; its web is 9" deep, and varying from 1" to 1½" in thickness. Give a vertical cross section, ¼ full size. (11.)

*5. Cross section through floor joists.

Draw, to a scale of $\frac{1}{12}$, adding 1½" floor boards, plaster pugging, and a lath and plaster ceiling. (11.)

*6. Cross section of a common rubble wall with moulded brick coping.

Draw, to a scale of $\frac{1}{24}$, showing the stones and 3 courses of tile creasing. (13.)

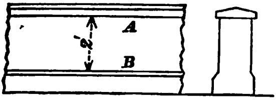
7. Draw, to a scale of 8 ft. to an inch, line diagrams of the following roof trusses:—

Collar beam truss for a 15 ft. span.

King-post truss for a 28 ft. span.

The names to be written on the different members.

(13.)



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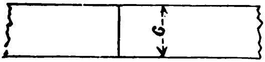

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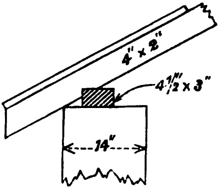

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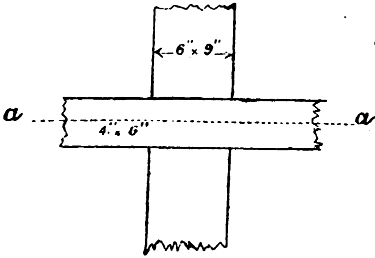

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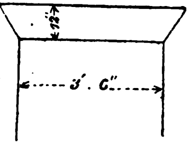

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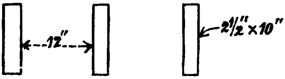

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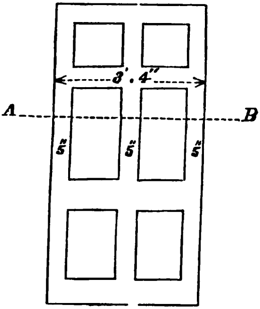

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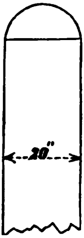

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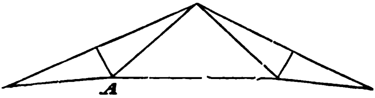


*13

*8. Section of 9″ × ¾″ roof boarding on rafters.

Draw, to a scale of 1″ to a foot, adding Countess slates, laid to a 4″ lap, and centre nailed. (14.)

9. Give drawings, to a scale of , explaining fully the following details :—

A butt joint, the timber being 9″ × 9″, and secured by ½″ iron fish plates.

The foot of a 12″ × 12″ wooden story post mortised into a stone base 16″ × 16 × 12″; the top of the base to be chamfered. (14.)

10. Give sketches showing the difference between a double floor with rolled girders, and a floor consisting of rolled girders, binders, and bridging joists. (14.)

*11. Elevation of the head of a door opening filled in with a common flat arch, used in inferior work, and known as a French or Dutch arch.

Draw, to a scale of $\frac{1}{12}$, showing by single lines the joints of the bricks forming the arch. (14.)

*12. Elevation of an outer door, 2½″ thick, framed and panelled, moulded outside and bead flush on inside.

Give a section through AB, to a scale of 1″ to a foot. (16.)

*13. A skeleton diagram of an iron roof truss for a 30 feet span.

Show what form of section you would adopt for each member; and give a detail drawing, half full size, of the joint at A. (18.)

14. Give a vertical section, to a scale of ⅛, through the sill of a double hung window sash, showing a stone sill, 11″ × 6″, resting on a 14″ brick wall, an oak sill 6″ × 3″, a 1½″ window board, and the bottom rail of a 2″ sash.

Also give a cross section through the meeting rails. (19.)

MAY, 1882.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. A and B are plans of two courses of bricks at the end of a wall.

Draw both courses, to the scale of $\frac{1}{12}$, altering A, if necessary, and showing on B the joints of the bricks by single lines.

Write against them the name of the bond. (11.)

*2. Cross section of a stone window sill in a 14″ brick wall.

Draw, to a scale of 1½″ to 1′, showing it throated and grooved for a metal weather tongue; also show the joints of the bricks at A. (11.)

3. Give a cross section, half full size, of a rolled iron floor joist, 4½″ × 9″, with a ⅜″ web and ¾″ flanges. (11.)

*4. Cross section of four battens 5″ × 1½″.

Draw, ⅓ full size, showing a rebated and beaded joint at A, a ploughed and tongued joint at B, suitable for floor boards, and a rebated and filleted joint at C, for the same purpose. (11.)

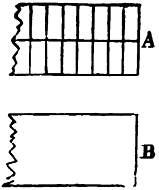
*5. Inside elevation of a small window opening.

Draw, to a scale of 1½″ to 1′, showing a 3″ wood lintel with a common brick discharging arch above, in two rings. No joints to be shown except those of the arch. (11)

*6. Elevation of the foot of a king-post at the centre of a tie-beam.

Give a section through AB, to a scale of $\frac{1}{12}$, showing all the details of a stirrup iron, with gibs and cotters. (13.)

7. Show, by means of a plan and section, the meaning of floor boards laid folding with broken joints. (13.)



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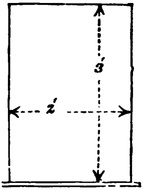

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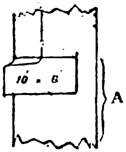

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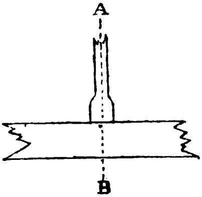

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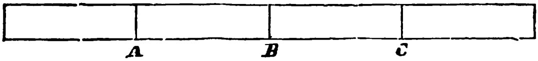

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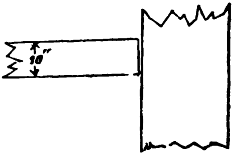

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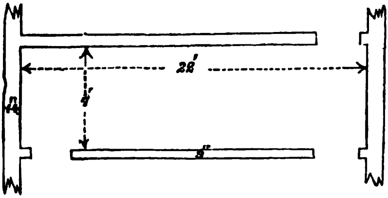

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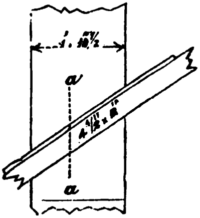

*14.

8. Show, by sections through the joint between two stones, the methods of connecting them together. 1st. By a lead plug; 2nd. By a metal cramp run with lead. (14.)

9. Give vertical sections, half full size. 1st. Through the bottom sash rail and the oak sill of a 1½″ double-hung window. 2nd. Through the meeting rails. (14.)

*10. Section through an 18″ brick wall, built in English bond, showing the end of a floor joist, which is to rest on a 4½″ × 3″ plate carried on brick corbelling.

Draw, to a scale of ¾″ to 1′, adding the wall plate and brick corbeling, and showing the joints of the bricks by single lines. (14.)

*11. Plan of a first floor passage.

Draw, to a scale of 4′ to an inch, showing the floor joists by single lines, with a well-hole 12′ × 3′ 6″ for the stairs.

Write their names against the different joists. (14.)

12. Give a vertical section, to a scale of $\frac{1}{12}$, through the panels of a 6′ 9″ door, framed as follows: 2″ deal, four panel, bead flush at bottom, moulded and flat at top, and square and flat at back. Top rail to be 5″, lock rail 10″, and bottom rail 9″. (16.

13. Draw a horizontal section, half full size, through one side of a window frame for double-hung 1½″ moulded sashes; taking ⅝″ inside and outside linings, 1¼″ pulley piece, ⅜″ back lining, ⅜″ parting bead, 1″ × ⅝″ inside bead, ¼″ parting slip.

The sash stile to be shown in the section. (18)

*14. Elevation of end of brick chimney shaft, with section through part of adjoining roof, showing slate, boarding, and rafter.

Draw, to a scale of 1½″ to 1′, adding 20″ Countess slates laid to a 3″ lap, with step flashings, etc., to keep out the weather. Give a section of the same through *aa*. (19.

MAY, 1883.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Elevation of six courses at the end of a 14″ brick wall, built in Old English bond.

Draw to a scale of 1″ to a foot, making any alteration you may consider necessary. (11.)

*2. Vertical section through the centre of the upper portion of a stone pier.

Draw to a scale of 1½″ to a foot, showing a stone cap 12″ deep at the centre, weathered and throated, and projecting 2″. (11.)

3. Draw to a scale of ⅓ a cross section of—

A 3″ deal with one edge chamfered and one edge beaded.

A 2″ batten tongued and grooved. (11.)

*4. Section of an iron girder.

Draw half full size, stating against it whether it is intended for a cast or a wrought iron girder. Without altering the dimensions, make any improvement in the form you may think advisable. (11.)

*5. Joint at the head of a small wooden roof truss.

Draw to a scale of $\frac{1}{12}$, making any corrections you may consider necessary. Write its name against the truss, and against each of the members shown. (12.)

*6. Elevation of part of a dwarf wall, with stone coping.

Draw to twice the scale, showing at A coursed rubble, and at B irregular coursed or snecked rubble. (12.)

7. Draw, to a scale of 8 feet to an inch, single line diagrams showing—

A king-post truss for a 25 feet span; rise to be ¼ span.

A queen-post truss for a 40 feet span; rise to be ⅓ span.

Write the names of the different members. (13.)

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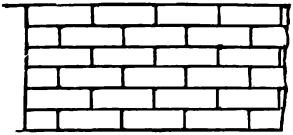

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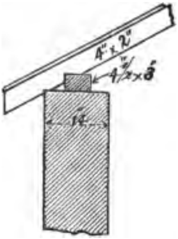

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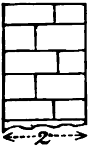

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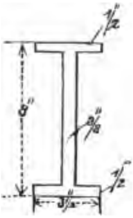

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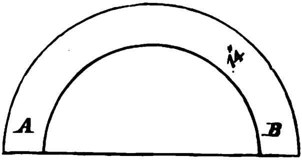

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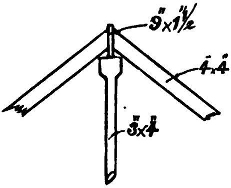

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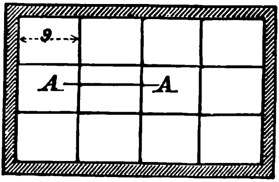

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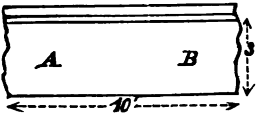

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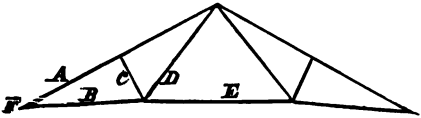


*14.

*8. Section through the eaves of a roof.

Draw, to a scale of $\frac{1}{12}$, adding three courses of slates, 20″ long, properly laid to a 4″ lap. Write their names against the different members. (13.)

*9. A semicircular opening in a brick wall.

Draw, to a scale of 1½″ to a foot, showing—
At A, six courses of a plain or rough arch.
At B, four courses of an axed or rough cut arch. (13.)

10. Give a vertical section, ¼ full size, through both the wood and the stone sills of a window opening for a 1½″ swing sash. The stone sill to be 6″ × 4″, weathered and throated, and to rest on a 9″ brick wall. The wood sill to be 4″ × 3″, with a 1¼″ inside bead, and a 1¼″ window board. (15.)

11. A room, 14′ wide, is to be divided in two by a quarter partition. It is to rest on the 4½″ × 3″ plates which carry the floor joists on brick offsets.

Give, to a scale 2 feet to an inch, an elevation of the framing of the partition, showing a central opening 7′ × 3′ for a door.

The scantlings, which are to be marked on the different members, are to be as follows:—

Sills - - - - - -	4″ × 4″
Studs or quarters - - -	4″ × 2″
Braces - - - - -	4″ × 2″
Door studs - - - -	4″ × 3″

The details need not be filled in on both sides of the doorway. (15.)

12. Draw, to a scale of ½″ to a foot, the back elevations of both a ledged door and a framed and braced door; to be 7′ × 3′, and put together in batten widths. (16.)

*13. Plan of a floor in which the girders are rolled iron joists 10″ × 4½″, and the binders of wood 9″ × 6″ resting on the top of the girders, and carrying 6″ × 3″ bridging joists, and 1½″ floor boards, 7″ wide.

Give a section, to a scale of $\frac{1}{24}$, through AA, showing the construction. (18.)

*14. A line diagram of an iron roof truss for a 25′ span.

Show what forms of section you would adopt for each of the members, A, B, C, D, E. Assuming the dimensions of A and B, give a detail drawing ⅓ full size, of the joint F, using a cast iron shoe to form the connection. (19.)

MAY, 1884.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Plan of a course of bricks at the end of a two-brick wall.

Draw, to a scale of $\frac{1}{12}$, the plan of the next course, and write against it the name of the bond. (11.)

*2. Longitudinal section through three coping stones.

Draw to a scale of $1\frac{1}{2}''$ to a foot, showing the joint A secured by a slate dowel, and B by a joggle. (11.)

*3. A is the plan and B the elevation of the end of a timber balk.

Show, at A, two such balks connected by $\frac{1}{2}''$ iron fish-plates, and at B by halving, to a scale of $1\frac{1}{2}''$ to a foot. (11.)

4. Give a vertical cross section, to a scale of $\frac{1}{8}$, through a cast-iron cantilever $9''$ deep, the flanges being respectively $4'' \times 1''$ and $2\frac{1}{2}'' \times \frac{5}{8}''$, and the web varying from $1''$ to $\frac{5}{8}''$. (11.)

---

*5. Inside elevation of a window opening in a brick wall.

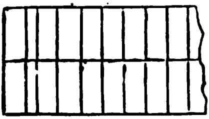
Draw the head of the window, to scale of $1\frac{1}{2}''$ to a foot, showing a wood lintel $4'$ long by $3''$ deep, with a discharging arch, in two rings, above it. The separate bricks of the arch rings need not be shown. (12.)

*6. Section of a coursed rubble wall faced with ashlar, with a through bondstone at A.

Draw it, to a scale of $\frac{1}{12}$, making any alteration you may deem necessary in the ashlars, and filling in the joints of the rubble work. (12.)

*7. Horizontal section through a door.

Draw to a scale of $1\frac{1}{2}''$ to a foot, showing the panel, at A, bead flush one side and square and flat at back and, at B, filled in solid. (13.)



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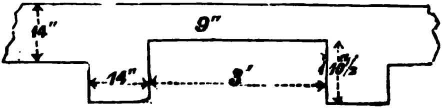

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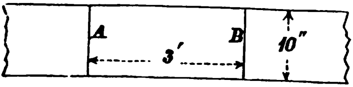

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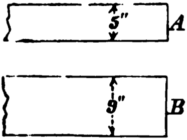

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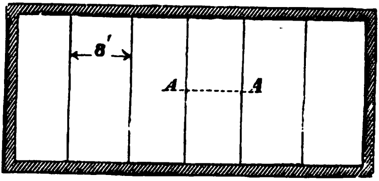

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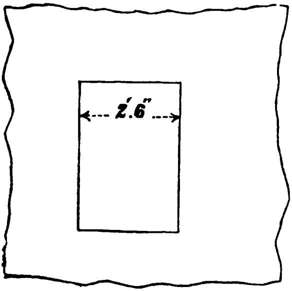

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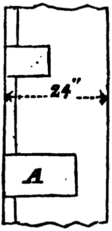

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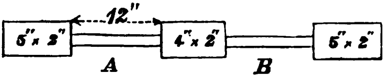


*7.

*8. Plan of a fireplace in the long side of a room.

Draw it to a scale of ½″ to a foot, adding trimming joists 10 × 2½″, trimmer 10″ × 3″, and trimmed joists 10″ × 2″.

Figure the scantlings on the different joists. (13.)

9. Show by sketches the meaning of the terms, "fox-wedging," and "chase mortise." (13.)

10. Give a cross section of a 2″ drip, in a lead gutter, half full size, showing 1″ boards and 3″ × 2″ bearers. (15.)

11. Give, to a scale of 3′ to an inch, an elevation of a collar beam roof truss, for a 12′ span.

Show 4½″ × 3″ wall plates resting on 14″ brick walls, rafters 5″ × 3″, collar 4″ × 2″ halfway up, ridge-piece 9″ × 1½″. (15.)

*12. Plan of a double floor showing position of girders.

Give a section through AA, to a scale of ¾″ to a foot, showing rolled iron girders 5″ × 10″, bridging joists 8″ × 2½″, floor battens 7″ × 1½″, and ceiling joists 4″ × 2″. (16.)

13. Draw a horizontal section, to a scale of ⅛, through one jamb of a 3′ doorway in a 14″ brick wall, showing a 4½″ reveal and the bricks laid in Flemish bond, a solid frame 5″ × 4½″, rebated and chamfered, and about half the door, which is to be framed and braced, with 5″ × 2″ hanging style and 4½″ × ¾″ battens. (18.)

14. Give an elevation, to a scale of 2′ to an inch, of a little more than half of a king-post roof truss, resting on 14″ brick walls, 20 feet apart, taking the following scantlings:—

Wall plates - - -	4½″ × 3″
Tie-beam - - - -	9″ × 3″
Principals - - - -	6″ × 3″
Struts - - - -	3″ × 3″
King-post - - - -	4″ × 3″

Heelstraps and stirrup iron 2″ wide. (19.)

MAY, 1885.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Elevation of part of the end of a brick wall built in Flemish bond.

Draw, to a scale of 1½″ to a foot, showing the bricks in the courses marked *a*. (11.)

*2. Elevation of part of a stone wall built of squared rubble, built up to courses.

Draw, to a scale of 2′ to an inch, showing the arrangement of the stones. (11.)

*3. Joint between the foot of a principal rafter and the tie-beam of a wooden roof truss, showing the end of the tie-beam resting on a brick wall.

Draw, to a scale of 2′ to an inch, making any alterations you consider necessary, and adding a heelstrap 2″ wide. (11.)

*4. Single line section of a cast-iron girder which is to be supported at both ends and loaded at the centre.

Draw, to a scale of 2″ to 1′, making the top flange 1″ thick, the bottom flange 1½″ and the web averaging 1¼″. (11.)

---

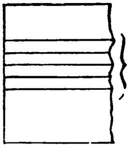
*5. Elevations of a stone arch.

Draw to twice the scale, writing against them the names of the following parts:—The lines AaA, BbB, and AB; a single stone of the arch, as C; the highest stone, D, of the arch; the spaces, E, over the arch. (12.)

6. Draw, to a scale of 3′ to 1″, a cross section through a couple roof, resting on 9″ brick walls 12′ apart. Rafters and wall plates to be 4″ × 2″, ridge board 7″ × 1½″. Only the four top courses of the walls to be shown, with the eaves projecting 9″. (12.)

*7. Side view of a stone corbel to carry a girder.

Draw, to a scale of $\frac{1}{12}$, a section of about 10 courses of an 18″ brick wall, showing the bricks and the corbel in position. (13.)



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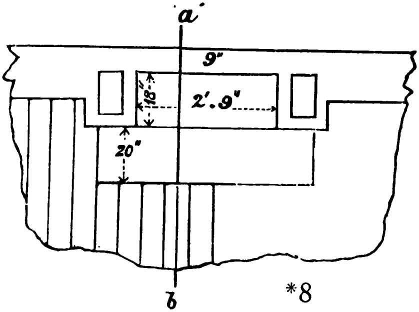

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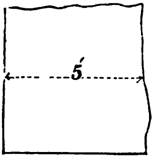

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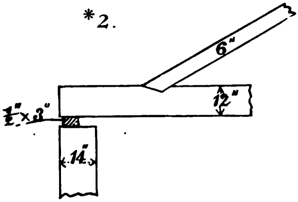

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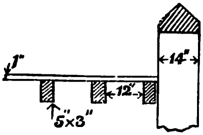

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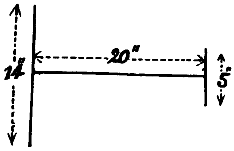

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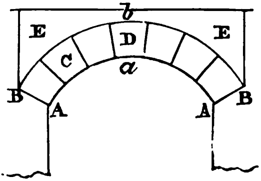

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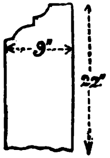

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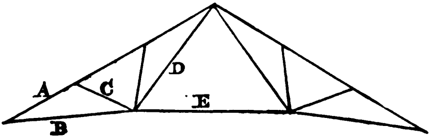


*14.

***8. Plan of part of the floor of an upper room, showing a fire place.**

Draw, to a scale of ¾" to a foot, a vertical section through *ab*, showing a trimming joist 9" × 3", common joists 9" × 2", floor boards 1¼", front hearth 3", back hearth 2", and a half brick trimmer arch. (13.)

9. Show by sketches the meaning of the following terms:—

Match boarding;
Mortise and tenon;
Haunched tenon.

State the object of the latter. (13.)

***10. Section through the gable end of a slate roof, showing a brick parapet with stone coping, common rafters and slate boarding.**

Draw, to a scale of $\frac{1}{12}$, adding Countess slates, and lead flashing, to keep the weather out. (15.)

11. Give an elevation, to a scale of 2' to 1", of little more than half of a naked wooden trussed partition, 10' high and 15' long, with a 7' × 3' central opening, from the following details:—Sills 4" × 5", and resting 6" on 3" stone templates in 14" brick walls; door studs 4" × 4"; all other scantlings 4" × 2". (15.)

12. Draw, to a scale of 6' to an inch, a single line diagram showing the form of a king-post roof truss for a 30' span, the rise being ¼ the span.

Write their names on the different members, and draw, ⅙ full size, an elevation of the joint at the top of the truss, the members consisting of a cast iron head, 5" × 5" timbers, and an iron rod 1¼" diameter. (16.)

13. Give, to a scale ⅓ full size, a horizontal section through one side of a window opening in a 14" brick wall, showing all the details connected with a wooden cased frame for 2" double hung sashes, with half brick reveals and plastered jambs. The joints of the brickwork need not be shown.

The following dimensions to be adopted:—1" inside lining, 1¼" pulley style and outside lining, ⅜" parting bead, ½" back lining and parting slip, 1½" × ¾" inside bead. A sash style to be shown. (18.)

***14. A line diagram of an iron roof truss for a 35' span.**

Show by sketches the form of section you would adopt for each of the members marked A, B, C, D, E.

Assuming the dimensions of A and B, give a drawing, ⅓ full size, of the joint connecting them, showing a cast-iron shoe, and some means of tightening up B. (19.)

MAY, 1886.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

You *must attempt three* of the first *four* questions. The remaining four you may select from any part of the paper.

*1. Segmental gauged arch over an opening in a brick wall.
Draw, to a scale of $\frac{1}{12}$, showing at A six courses of the arch bricks, starting from the springing. (11.)

2. Section of a coursed rubble dwarf wall.
Draw, to a scale of 1½″ to a foot, showing the construction, and adding a 6″ stone coping weathered and throated. (11.)

*3. Sections of the flanges and web of a cast-iron cantilever.
Draw the section of the cantilever ⅓ full size. (11.)

*4. Head of a king-post in a wooden roof truss.
Draw, to a scale of ⅛, adding the heads of the principals 6″ × 4″, and a ridge board 11″ × 2″, and making any alteration you think necessary. (11.)

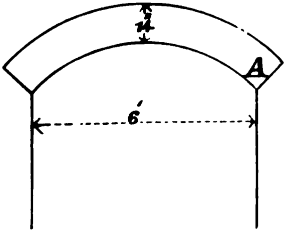
---

*5. Elevation of a window opening with a stone lintel, the depth of which is equal to four courses of bricks.
Draw, to a scale of ¾ of an inch to a foot, a vertical section through AA, the wall being 18″ thick, with a 9″ × 3″ wood lintel, and a discharging arch of two half brick rings. (12.)

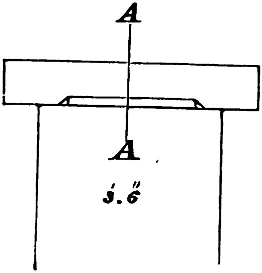
*6. Cross section of a beam and iron flitch, which are to be formed into a flitch girder.
Draw the section of the girder to a scale of $\frac{1}{12}$, showing ¾″ bolts by dotted lines. (12.)

7. Show by sketches the meaning of the following terms in carpenters' work:—
Birdsmouth—mortised and housed—dovetail-halving. (13.)

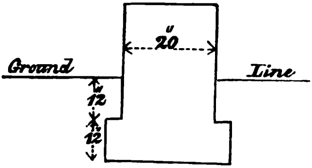
8. Draw a cross section, to a scale of ½″ to a foot, showing a 9″ sleeper wall supporting a single joist floor. (13.)


14"
A
6'

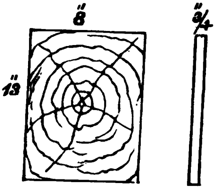
*1.


A
A
3'.6"

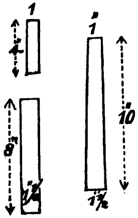
*5.


20"
Ground
Line
12"
12"

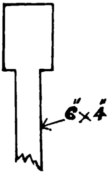
*2.


8"
13"
3/4"

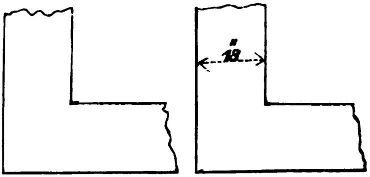
*6.


1
4"
8"
1¼"
1"
10"
1½"

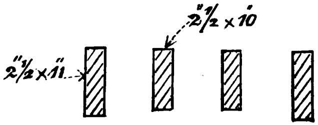
*3.


6"×4"

*4.


18"

*9.


2½"×10'
2½"×11"

*10.

*9. Plan of two successive courses of brickwork at the angle of a building.

Draw, to a scale of ¾″ to a foot, showing the bricks laid in English bond. (13.)

*10. Cross section through four common joists, 15″ from centre to centre.

Draw, to a scale of $\frac{1}{12}$, adding 1½″ floor boards and 3″ × 2″ ceiling joists, also sound boarding and pugging. (15.)

11. Draw a horizontal section through a 2½″ framed and panelled door, to a scale of ¼.

The door to be 3′ 6″ wide, with 5″ margins, one panel to be square and flat and moulded one side, and the other to be bead butt both sides. (15.)

12. Draw, to a scale of 3′ to an inch, an elevation of a little more than half of a queen-post roof truss for a 35′ span, from the following details:—

Tie-beam - - - -	5″ × 9″
Principals - - - -	5″ × 6″
Queens - - - - -	5″ × 3″
Straining beam - - -	5″ × 8″

Stirrup irons and heel straps to be 2″ × ¼″. (16.)

13. Give a horizontal section, to a scale of ⅛, through a little more than half of a French casement window, 3′ 6″ wide, in an 18″ wall, showing folding sashes opening outwards.

The inside of the frame to be flush with the inside of the wall, and the joint between the frame and wall to be covered with a plain chamfered architrave.

Give a freehand section of the bottom rail and sill, showing how you would keep out the weather. (18.)

14. The cast iron columns supporting a floor are of 1″ metal, 7″ mean outside diameter, and 10′ long.

Rolled iron joists, 12″ × 5″, meeting at right angles on the heads of the columns, carry a flat concrete floor 7″ thick.

Give a sectional elevation, to a scale of an inch to a foot, through the concrete and one of the joists, showing the connection of the cross girders on the head of the column. (18.)

MAY, 1887.

FIRST STAGE OR ELEMENTARY EXAMINATION

INSTRUCTIONS.

You are only permitted to *attempt seven* questions.

*1. Plans of two successive courses of a brick wall built in single Flemish bond.

Draw to a scale of $\frac{1}{12}$, showing the arrangement of the bricks. (11.)

*2. Elevation of part of the end of a stone wall.

Draw, to a scale of 2′ to an inch, showing at A squared rubble built up to courses, and at B block-in-course work, with plain ashlar quoins to both. (11.)

*3. Plan of the joint between a trimmer and a trimming joist.

Give a vertical section through A—A, to a scale of $\frac{1}{8}$, and show which is the trimmer. (11.)

*4. Cross section through a roof gutter behind a brick parapet.

Draw, to a scale of $\frac{3}{4}''$ to a foot, adding the bricks, slate boarding and tilting fillet, lead gutter and flashing. (11.)

5. Give sketches explaining the following terms in carpenters' work :—

Plain fished joint—cogged joint—stump tenon. (12.)

*6. Vertical section through the footings of an external wall of a brick dwelling-house, the brickwork resting on the soil.

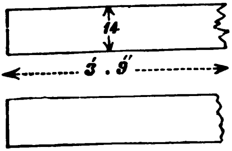
Draw, to a scale of $\frac{1}{2}''$ to a foot, making any alteration to the footings you think necessary, and showing the bricks laid in English bond. Nothing but brickwork to be shown. (12.)

*7. Line diagram of an iron roof truss.

Give, to a scale of $\frac{1}{3}$, a detailed drawing of the joint at A, the struts being of angle iron, $3'' \times 3'' \times \frac{5}{8}''$, the tie-rod 1″ diameter, and the king-rod $\frac{3}{4}''$ diameter. (12.)

*8. Section through the eaves of a roof.

Draw, to a scale of 1″ to a foot, adding 1″ slate boarding covered with Countess slates, 20″ × 10″, laid to a 3″ lap and centre nailed. The slating to show 4 margins. The thickness of the slates may be exaggerated to show the details distinctly. (13.)



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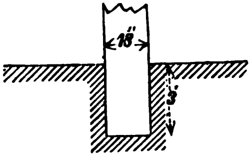

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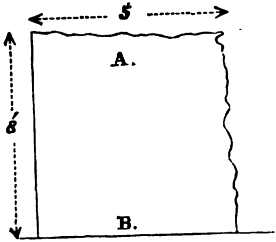

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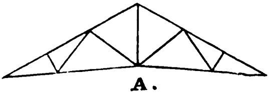

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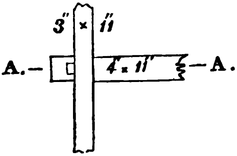

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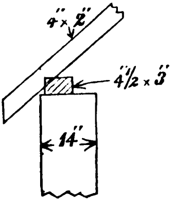

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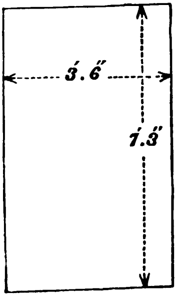

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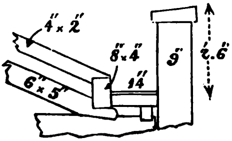

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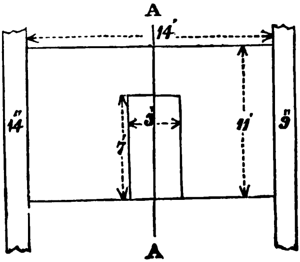


*11.

*9. Show, by a section ½ full size, how an iron bar, 1¼″ diameter, would be leaded into a block of stone.

Give sketches showing the difference between a joggle and a dowelled joint in masonry. (13.)

10. Draw, to a scale of 1″ to a foot, the end of a floor joist 9″ deep, notched on to a 4″ × 3″ wall plate carried on brick corbeling, the wall being 14″ thick. The section of the wall to show the method of corbeling out the bricks. (13.)

*11. Elevation of a trussed partition between two rooms.

Draw, to a scale of $\frac{1}{24}$, the portion to the left of the line A—A, showing the following details, and how it is supported, as well as any ironwork you may consider necessary:—

Head - - - - -	4½″ × 6″	
Sill - - - - - -	4½″ × 4″	
Quarter or studs - -	4½″ × 2″	
Door studs - - -	4½″ × 4″	
Braces - - - - -	4½″ × 3″	
Nogging pieces (one row) -	4½″ × 2″	(14.)

12. Give, to a scale of ¾″ to a foot, sections, at right angles to the direction of the floor boards, showing the difference between a double and a framed floor.

The double floor to be finished with 1½″ rebated boards, and the framed floors with 1½″ battens, rebated and filleted.

Their names to be written against the different members. (15.)

13. Draw, to a scale of ¼, a horizontal section through a window jamb in a 14″ wall, showing the details of a cased frame for 2″ double hung, moulded, sashes.

Give the section of a sash style, and write their names and dimensions against the different members of the frame. (16.)

*14. Front elevation of a framed and braced door with 6″ styles, 7″ top rail, 9″ bottom rail, 10″ lock rail, and 6″ braces, and filled in with 5″ battens.

Draw, to a scale of $\frac{1}{18}$, showing by dotted lines the members at the back of the door. (16.)

MAY, 1888.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Cross section of a stone to be formed into a window sill.

Draw, to a scale of ¼, the finished cross section, at the centre, showing it weathered, throated, and grooved for a metal tongue. (11.)

*2. Cross section of six courses of a 2½ brick wall built in English bond.

Draw, to a scale of an inch to a foot, making any alteration you may think necessary. (11.)

*3. A and B are sections through a wooden floor girder and a bridging joist.

Draw, to a scale of ⅕, two cross sections of the girder, showing the joist notched to it in the one case, and cogged to it in the other.

The cogged joint to be marked C, and the notched joint N. (11.)

*4. A is the section of a stone string course. B is a part cross section of a coursed rubble wall built of a thin bedded stone occurring in layers of from 4" to 8" thick.

Draw B, to a scale of 1½" to a foot, showing the stones, and inserting the string course at *a*. (11.)

5. Explain by sketches the following terms:—

Return or staff bead.
Rebated and beaded boards for partition.
Shouldered or tusk tenon. (11.)

*6. Elevation of a 9" arch ring, over an opening in a brick wall built in Flemish bond. Span of arch 6', and rise 12".

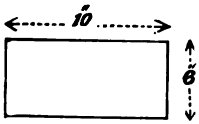
Draw, to a scale of ¾" to a foot, showing 4 courses of the arch bricks at A, and 4 courses of the wall bricks at B. (12.)

*7. Drawing of a stone template to carry the end of a cast-iron girder 10" deep, with flanges 1¼" × 8" and ¾" × 3".

Draw the girder, ⅓ full size, in cross section, showing the template in elevation. (12.)

8. Draw, to a scale of $\frac{1}{48}$, line diagrams showing the difference between a wooden king-post and queen-post roof truss; one for a span of 36', and the other for a 24' span.

Write their names against the different members. (13.)



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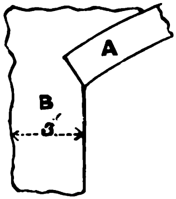

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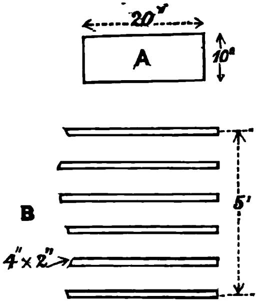

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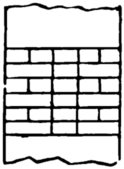

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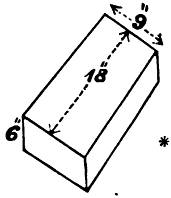

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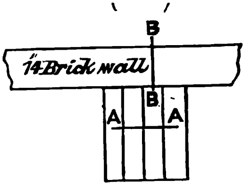

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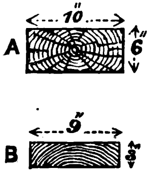

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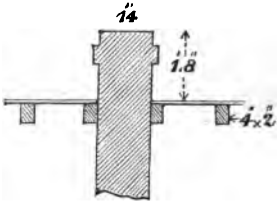

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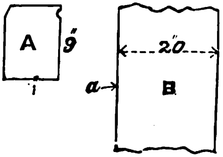

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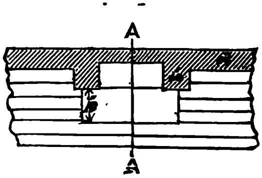

*13.

*9. Section through a portion of a slate roof divided by a party wall.

Draw to a scale of $\frac{1}{12}$, showing the slates, with two different methods of using lead to form a watertight joint between them and the wall.

The thickness of the slates should be exaggerated, and the section should pass through a lap. (13.)

*10. A is a plan of a roofing slate.

By what name is this sized slate known ?

B is a plan of the ends of 6 common rafters at the eaves of a roof.

Draw B, to a scale of $\frac{1}{2}''$ to a foot, adding 9" slate boarding, a tilting fillet, and slates, as A, laid to a 4" lap.

Put 5 slates in width in the doubling eaves course, and one less in each of the four following courses.

The nail holes where exposed to show centre nailing. (13).

11. Draw to a scale of $\frac{1}{12}$, a vertical cross section through the joint between the king-post and the tie-beam, the latter being 11" × 6" in a timber roof truss.

Show the full details of the stirrup, etc., before tightening up. (14.)

*12. Plan of part of a stone stair.

Draw, to a scale of $\frac{3}{4}''$ to a foot, a section through A—A, showing square steps with rebated joints, a 6" rise and moulded nosings.

Also a section through B—B. (15.)

*13. Plan of part of a first-floor room in a dwelling-house, the boards being carried on common joists 10" × $2\frac{1}{2}''$, trimming joists and trimmers 10" × 3".

Give, to a scale of $\frac{1}{2}''$ to a foot, a vertical section through A—A, showing a brick trimmer arch and a lath and plaster ceiling below. (16.)

14. Give, to a scale of $\frac{1}{5}$, a horizontal section through one jamb of an entrance doorway to a dwelling-house, the outer walls being 18" brickwork with chamfered stone quoins to openings.

The following to be shown :—

Inner face of wall plastered flush with door frame.
Single architrave to door frame.
Hanging style of door 6" × $2\frac{1}{2}''$.
Panel (part only) bead flush and moulded at back.

(16.)

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MAY, 1889.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plan of the angle of a brick building built in English bond.

Draw, to a scale of ½" to a foot, showing the joints of the bricks by single lines. (11).

*2. Sketch, showing the end of a beam to be connected with a similar one by an ordinary scarfed joint.

Give a plan and elevation of the joint to a scale of 1" to a foot. (11.)

3. Explain, by sketches or otherwise, the following terms:—edges shot—ploughed, tongued and V jointed—mortised and housed. (11.)

*4. Section of a stone wall built of coursed, flat bedded, rubble.

Draw, to a scale of ¾" to a foot, showing the stones in the wall, including two ¾ bond stones, and adding a flushed stone coping, weathered at top. (11.)

*5. Vertical cross section through the joints of a stone landing.

Draw, to a scale of $\frac{1}{12}$, showing at A a rebated joint, and at B a joggled joint. (11.)

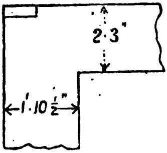
*6. Single line section of a cast-iron girder, 10" × 4" × 15" deep.

Taking the thickness of the top and bottom flanges at 1½" and 1" respectively, draw its section, ¼ full size, and state how such a girder ought to be used. (12.)

7. Draw, to a scale of ¼, cross sections of the joints you would use in the lead gutter of a roof to connect the ends of the sheets together. (12.)

*8. Elevation of the back of a framed and braced door.

Draw, to a scale of ¾" to a foot, making any alteration you think advisable, and filling in with rebated and beaded battens. Only the joints in connection with the hanging stile to be dotted in. (13.)



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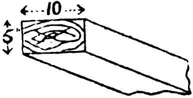

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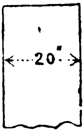

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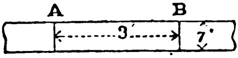

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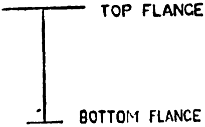

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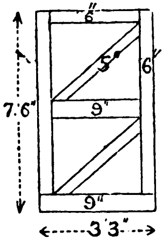

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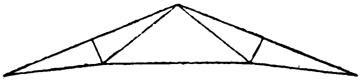

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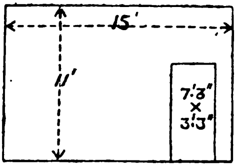

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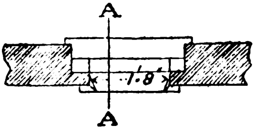

14*

9. Give, to a scale of ¾″ to a foot, sections across a few floor boards, showing the construction of:—

A single floor with 1½″ boards, rebated and filleted.
A double floor with 1½″ boards, grooved and tongued.

*10. Line diagram of an iron roof truss.

Draw, ⅓ full size, an elevation of the joint at the head of the truss, the members consisting of ⊤ irons, 2¾″ × 2½ × 1½″, and two bars 2¼″ × ¼″. (13.)

11. Draw, to a scale of 3′ to an inch, a cross section through a wooden roof over a 16′ span, showing:—

Rafters - - - -	4″ × 2″
Collar - - - -	4½″ × 2″ half way up
Ridge Piece - - -	7″ × 1½″
Wall Plates - - -	4″ × 2″
Brick Walls - - -	14″.

The rise to be ⅓ span, and the rafters not to be weakened in connecting the collar to them. (14.)

12. Draw to a scale of ⅛, a cross section through a lead gutter at the back of a chimney shaft, showing all the details of construction, the rafters being 4″ × 2″, carrying Countess slates (3 courses to be shown) on ¾″ boards. (15.)

*13. Elevation of a 4½″ trussed partition, to be constructed out of 9″ × 3″ and 9″ × 2″ deals.

Give its elevation, to a scale of 3′ to an inch, writing against them the names and scantlings of the different members. (16.)

*14. Horizontal section through a window, 1′ 8″ × 2′ 6″ to be fitted with a casement sash, hung to a solid frame, and opening inwards.

Draw a vertical section through A—A, to a scale of 1½″ to a foot, showing a stone head and sill, a 1¼″ window board, and a 2″ sash, which must be weather-tight. (16.)

MAY, 1890.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plan A represents one course at the end of a brick wall built in Flemish bond.

Draw to a scale of 1″ to a foot, making any alteration you think necessary. Also draw plan B, showing the arrangement of the bricks in the next course. (11.)

2. Give a sketch elevation showing a portion of a stone wall built of squared rubble worked up to courses. (11.)

*3. Elevation showing two 13″ square balks of timber halved together.

Draw the joint to a scale of ¾″ to a foot, but showing it tabled and secured by hardwood wedges, without any bolts. (11.)

*4. Plan of a beam cogged on to a wall-plate.

Give a section through *a—a* to a scale of 1″ to a foot. (11.)

*5. Elevation of a stone arch.

Draw to twice the scale, and write on it the names of all the different parts of the structure. (11.)

6. Explain by aid of sketches the meaning of the following terms:—wood plugs, lead dots, double quirk bead, wood lintel. (12.)

*7. Parts of a roof truss. One member of each kind being given.

Draw the truss to a scale of 4 ft. to an inch, writing down the name of the truss and of its different members, including any ironwork. (12.)

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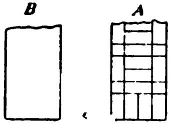

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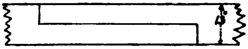

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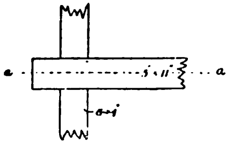

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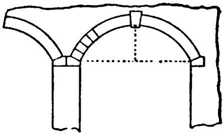

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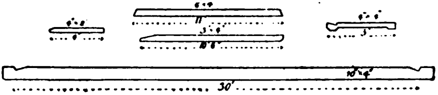

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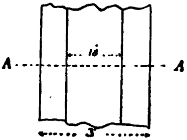

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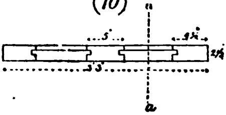

*8. Plan of part of an 18″ brick wall built in English bond, showing also the width of the bottom course of footings.

Draw the plan, to a scale of ¾″ to a foot, filling in the bricks in the 18″ course only.

Draw a vertical section through A—A, showing the arrangement of the bricks in the footings, no offset to be more than a ¼ brick. (13.)

9. A cast iron cantilever is 10″ in depth, and its flanges are respectively 4″ × ¾″ and 8″ × 1¼″.

Draw its section in position, one-third full size. (13.)

*10. Horizontal section through a 4-panelled door, 7′ high.

Draw its outside elevation, and a vertical section through *a—a*, to a scale of ¾″ to a foot, showing the top panels bead butt, and the bottom panels bead flush. (13.)

11. Draw, to a scale of 1½″ to a foot, a section through the eaves of a roof, showing 4½″ × 2″ rafters, with 3″ × 1″ battens, carrying 24″ slates.

Show four courses of slates, centre nailed, and laid to a 4″ lap. (14.)

12. An iron roof truss over a 24′ span consists of tee iron principals 3″ × 2½″ × ⅜″, two angle iron struts, 1½ × 1½″ × ⅜″, and 5 tension rods of ⅞″ diameter.

Draw the elevation of about half the truss, to a scale of 2′ to an inch. (15.)

13. Draw a cross section, to a scale of 1″ to a foot, through an 8″ lead gutter with step-flashings, formed at the end of a boarded and slated roof butting against the brick wall of another building. Also show the step-flashings in elevation. (16.)

14. Draw a vertical cross section, to a scale of 1½″ to a foot, through the foot of a wooden king-post, and a tie beam 5″ × 11″, showing all the details of a stirrup iron ⅜″ thick, properly wedged up with gibs and cotters. (16.)

MAY, 1891.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Plans of two successive courses of brickwork at the angle of a building.

Draw, to a scale of ¾″ to a foot, showing the bricks arranged in single Flemish bond. (11.)

*2. A represents the ends of two wall plates at the angle of a building, to be halved together.

B represents the end of a wall-plate on a cross-wall, to be bevel halved on to a main wall-plate.

C represents the ends of two wall-plates to be connected by scarfing.

Draw, ⅓ full size, the sections *a—a* through the finished joints; showing 4½″ × 3″ plates in each case. (11.)

*3. Elevation of part of a window opening in a brick wall.

Draw, to a scale of $\frac{1}{18}$, completing the elevation of the stone sill; and showing at A the bricks laid in English bond. (11.)

*4. Give a vertical cross section through B—B, Fig. 3, to a scale of ¼, showing a 5″ × 11″ stone sill, weathered, throated, and grooved for metal tongue, and resting on 14″ brickwork. (11.)

*5. Part elevation at an angle of a stone building.

Draw, to a scale of ¾″ to a foot, showing a facing of random rubble, with hammer-dressed joints and no spalls; also cut stone quoins. (12.)

6. Draw, to a scale of $\frac{1}{96}$, a line diagram showing a queen-post roof truss for a span of 36 feet, with a rise of ¼ span.

Write their names against the different members.

State why a king-post truss should not be used for this span. (12.)

*7. Elevation of the head of a solid door frame.

Draw, to a scale of ¾″ to a foot, making any alteration you think necessary.

Give a section through A—A, showing a beaded frame, rebated for a 2¼″ door. (12.)

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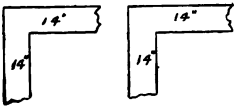

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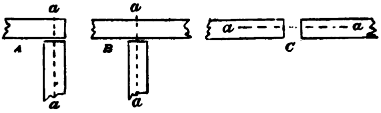

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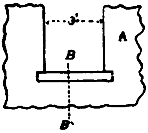

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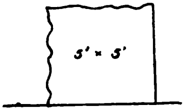

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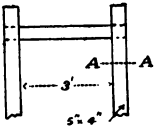

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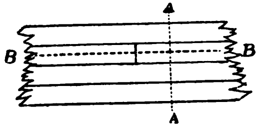

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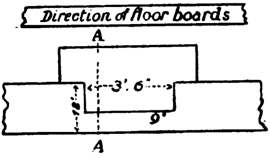

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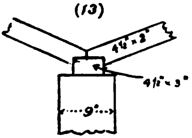

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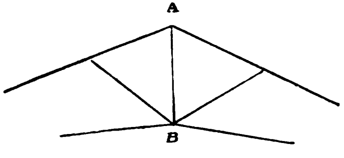

8. Show by sketches the meaning of the following terms in carpenters' work :—

Cross-grooving ; cockbead ; mortising and housing for rails, as applied to the head of a timber post ; panelled square and flat, and moulded one side. (13.)

9. Draw, to a scale of 3′ to an inch, an elevation of a wooden collar roof, over a 16′ span.

Rafters to be 4½″ × 2″, collar 4½″ × 2″, ridge board 8″ × 1½″, wall-plate 4½″ × 3″. Eaves to overhang one and a half brick walls 9″. (13.)

*10. Plan of part of an ordinary wooden floor.

Draw, to a scale of 1½″ to a foot, a section through A—A, showing 1¼″ battens, rebated and filleted ; also a section through B—B, showing a bevelled heading joint, and three joists, 11″ × 2″, spaced 12″ apart. (14.)

11. Draw, to a scale of ⅙, a vertical cross section through a solid window frame, fitted with a 1½″ pivoted sash, 2′ high, which is to be shown half open. (14.)

*12. Horizontal section through a fireplace on an upper floor.

Draw, to a scale of 1″ to a foot, a plan, and also a cross section through A—A.

The plan to show how the wood floor is carried round the hearth, with the names of the different joists written against them,

The section to show the front and back hearth-stones, and how they are carried. (15.)

*13. Section through a gutter at the centre of an M-roof.

Draw, to a scale of 1½″ to a foot, adding ¾″ slate, and gutter boarding, and a lead gutter ; and, on one side, Countess slates laid to a 4″ lap. (15.)

*14. Elevation of part of an iron roof truss.

Draw, to a scale of 3′ to an inch, elevations of the joints at A and B, the different members consisting of tee irons 3½″ × 3″ × ½″ and 2½″ × 2½″ × ⅝″, and 1⅛″ round iron. (16.)

MAY, 1892.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

*1. Part elevation of both the end and face of a brick wall built in Flemish bond.

Draw, to a scale of ¾″ to a foot, filling in the joints of the bricks by single lines. (11.)

2. Draw, to a scale of 2″ to a foot, a cross section through the top of a 14″ dwarf brick wall, showing a 5″ stone coping weathered and throated, with an iron rail, 1″ diameter, let into the top and run with lead. (11.)

*3. AA and BB are the ends of timber beams to be jointed together.

Draw, to a scale of ¾″ to a foot, showing at AA a butt joint with timber fish plates; and at BB a scarfed joint to take compression, secured with iron fish plates. (11.)

4. Explain clearly by sketches the meaning of the following terms in connection with masonry joints :—

Metal cramp run with lead.
Bed plug.
Lead plug. (11.)

*5. Elevation of part of a window opening in a wall of random rubble built up to courses.

Draw, to a scale of ½″ to a foot, showing the stonework at A, finished with cut stone quoins, and completing the window head with an equilateral stone arch. (12.)

6. Draw the following, to a scale of $\frac{1}{12}$:—

A cross section of a 16″ rubble sleeper wall, 2′ above ground level, carrying a 4½″ × 3″ plate.

An elevation of a rough inverted arch in two half-brick rings, for a 4′ opening, distributing the pressure over a concrete foundation. (12.)

*7. Section through 4 joists of a single floor.

Draw, to a scale of 1½″ to a foot, adding—1½″ floor boards, showing a bevelled heading joint—sound boarding and pugging—and lath and plaster ceiling. (12.

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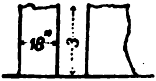

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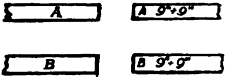

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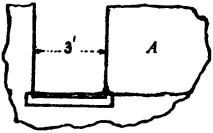

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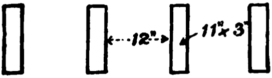

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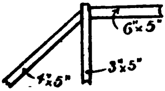

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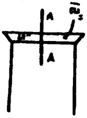

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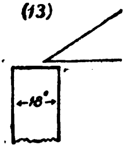

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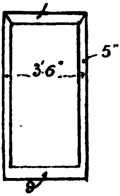

*8. Elevation of one of the joints at the head of an ordinary timber roof truss.

Draw the same properly, to a scale of $\frac{1}{6}$, showing the details of the joint, including a 2″ wrought-iron strap, and giving the names of the members shown. (13.)

9. Give sketches explaining the following terms:—
Tilting fillet and doubling eaves course.
Step flashing to brick chimney. (13.)

10. Draw a section, to a scale of $1\frac{1}{2}$″ to a foot, through a double floor consisting of rolled iron girders 10″ × $4\frac{1}{2}$″, common joists $2\frac{1}{2}$″ × 8″, and $1\frac{1}{2}$″ battens, ploughed and tongued with hoop iron.

The section to show six battens. (14.)

11. Draw single line diagrams, to a scale of 8′ to an inch, showing the ordinary forms of timber roof trusses used for spans of 18′, 25′, and 40′ respectively.

Give the names of the trusses and of their different members. (14.)

*12. Front elevation of a gauged brick arch over a window opening in a 14″ brick wall.

Draw, to a scale of $1\frac{1}{2}$″ to a foot, a cross section through AA, showing a 3″ lintel, with a rough discharging arch in two half-brick rings; also a $1\frac{1}{2}$″ head to window frame, with $\frac{3}{4}$″ inside, and $\frac{1}{2}$″ outside linings, $\frac{3}{4}$″ soffit lining, and the upper rail of a $1\frac{3}{4}$″ top sash. (15.)

*13. Elevation of one end of an iron roof truss, resting on a brick wall, the principal rafter being $4\frac{1}{2}$″ × $3\frac{1}{2}$″, and the tie rod $1\frac{1}{4}$″.

Draw, to a scale of $1\frac{1}{2}$″ to a foot, adding a cast-iron shoe bolted down to a 6″ stone template.

The tie rod to be adjusted by a screw nut at back of shoe. (15.)

*14. Outside elevation of a framed and braced outer door.

Draw, to a scale of $\frac{3}{4}$″ to a foot, making any alterations you consider necessary, and filling in with chamfered battens.

The joints to be shown by dotted lines, as well as the rails and braces not seen. (16.)

MAY, 1893.

FIRST STAGE OR ELEMENTARY EXAMINATION.

INSTRUCTIONS.

You are only permitted to attempt *seven* questions.

1. Give sketches, quarter full size, showing
   (*a.*) Three 1½″ floor *boards* with rebated joints, face nailed to a 9″ joist.
   (*b.*) Three 1½″ floor *battens* with dowelled joints, secret nailed to a 9″ joist. (11.)

*2. Plan of part of one course in a 2½ brick wall, built in English bond.
Draw, to a scale of 1″ to a foot, making any alteration you may think necessary, and show by dotted lines, on the same plan, how the bricks should be arranged in the next course. (11.)

*3. External elevation of a window opening in a brick wall.
Draw, to a scale of 1″ to a foot, the head of the same, showing a straight gauged arch, and giving all the joints of the bricks composing it. (11.)

*4. Elevation of the foot of an iron king rod in a timber roof truss.
Draw, to a scale of ¾″ to a foot, adding 4½″ × 2″ struts, and any other details necessary to complete the joint. (11.)

*5. Elevation of part of the end of a stone building just above the ground line.
Draw, to a scale of ½″ to a foot, showing a rusticated stone plinth 22″ high, ashlar quoins, and coursed rubble walling. (12.)

*6. A is the section of a wall plate carrying the end of a joist.
Draw to the same scale, showing the joist cogged down to the plate.
B is the foot of a wooden upright, secured by fox-wedging to a wood sill sunk in a concrete floor.
Draw, to the same scale, showing the details of the joint in section. (12.)

7. Give sketches explaining the use of the following :—

Lead tingles.
Tile creasing.
Stone corbels. (12.)

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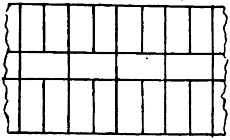

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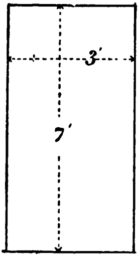

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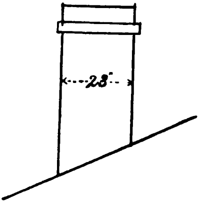

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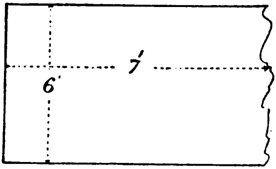

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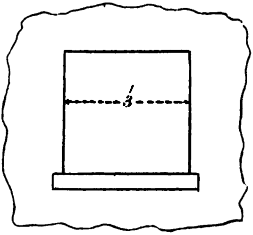

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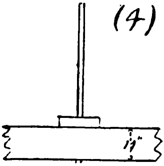

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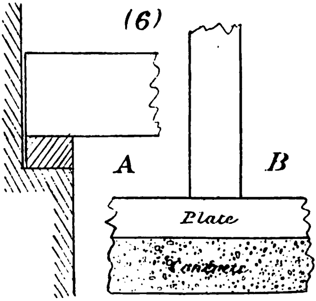

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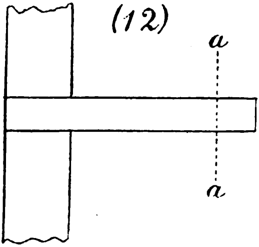

8. Draw, to a scale of ¾″ to a foot, a cross section of a 9″ brick sleeper wall, 18″ high, carrying a wooden floor, the joists being 6″ × 2½″. (13.)

9. Draw, to a scale of 2′ to an inch, the elevation of about one-half of a roof truss for a 26′ span, showing the following details, the rise being quarter the span :—

Wall plates, 4½″ × 3″.
Principals, 5″ × 4″.
Tie-beam, 11″ × 5″.
Struts, 4″ × 3″.
King post, 5″ × 4″.
Purlins, 8″ × 5″.
Pole plates, 8″ × 3″. (13.)

*10. Elevation of a brick chimney shaft, rising through a slate roof.

Draw, to a scale of ¾″ to a foot, a cross section through the shaft, showing the details of the leadwork and fixing, including two courses of 18″ slates, both above and below the shaft. (14.)

*11. Elevation of the back of a ledged and braced battened door.

Draw, to a scale of ¾″ to a foot, showing it hung to a 2″ frame, with cross-garnet strap hinges. (14)

*12. Elevation of a cast-iron cantilever, 9″ deep, built into a wall.

Draw, one-third full size, a vertical section through *a—a*, one flange being 6″ × 1″, and the other 2½″ × ⅝″ ; also an end elevation of the wall end of the cantilever.

(15.)

13. Draw, quarter full size, an elevation of the joint at the head of a king rod in an iron roof truss, from the following details :—

King rod, ¾″ diameter.
Rafters of tee-iron, 2½″ × 3″ × ⅜″.
Slope of roof, 30°. (15.)

14. Draw a vertical cross section, to a scale of 1½″ to a foot, through the bottom of a window opening, showing an oak sill 7″ × 3″, weathered and grooved for iron tongue ; a stone sill, 9″ × 5″, weathered, throated and grooved, and resting on 14″ brickwork ; a 1½″ window board ; the wall rendered inside, and finished at floor with 1¼″ torus moulded skirting 9″ high, scribed to floor.

(16.)

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